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## **Abstract**

The present study is an introduction to auction theory. The scope of this dissertation is to give a short and comprehensive, yet complete and accurate, guide on the topic of auctions. From a methodological point of view, an attempt has been made to present both that auctions are relevant in today's world and economy, and that they can be explained in a simple manner. First, this paper explores the ways auctions have been used and how they have evolved across the ages, and, secondly, it studies the main aspects of auction theory and the most common types of auctions. This paper is directed to students of any level or area of study and to the general public, aiming to inform and raise awareness on the matter of auction theory.

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## Introduction

Two new records were set concerning art auctions recently. On May 14, 2019, during the Impressionist and Modern Art Evening Sale at Sotheby's, Claude Monet's *Meules* (1890), from the artist's *Haystacks* series, became the first work of Impressionist Art to sell for more than \$100 million at auction. In fact, this sale garnered a price about forty-four times higher than the sum of \$2.5 million the painting's previous owner paid to acquire the artwork in 1986 (Loft, 2019). A day later, the sculpture *Rabbit* (1986) by Jeff Koons was sold for \$91 million during Christie's Post-War and Contemporary Art Evening Sale and broke the record for the most expensive work of art by a living artist sold at auction, surpassing the \$90.3 million for the painting *Portrait of an Artist (Pool with Two Figures)* by David Hockney—which was sold just last November (Reyburn, 2019). From record-breaking art pieces to websites hosting so-called “virginity auctions”, auctions are a source of both inspiration but also controversy.

Auctions are typically considered as a price-determination mechanism. “First and foremost, an auction is a way of allocating an object or acquiring a service” (Hubbard & Paarsch, 2015, p. 5). Dixit and Nalebuff (2008) aptly describe the typical image of an auction along with the proverbial saying “Going once... going twice... sold!”: it is that of “an auctioneer with a snooty British accent calling out to a hushed room of bejeweled art collectors sitting in Louis XIV chairs and tugging at their ears to bid.” This is because “An auction is a market mechanism, operating under specific rules, that determines to whom one or more items will be awarded and at what price” (Mochón & Sáez, 2015, p. 1). Besides, the general public and economists support that “the idea that auctions function to establish a ‘fair’ price is incontrovertible; by their definition, the auction price is both correct and fair since it is the price at which market supply and demand curves cross” (Smith, 1989, p. 112). This is why auctions are usually used in the sale of assets for which there is no established market or the market is likely to be very thin. For example, rare or unique objects are typically sold in auctions, but auctions are also used to sell Treasury bills (usually in simultaneous auctions). As Menezes and Monteiro (2005) explain, “only governments can legally produce such bonds and therefore the sale in an auction is an exercise in revenue maximization” (p. 9).

Auctions can be classified according to several distinct criteria. We can distinguish them between open auctions and sealed-bid auctions. In the former type of auction, all bids are publicly observable whereas in the latter they are not. We can also differentiate

between ascending (starting at a low price with increasing bids) and descending price auction (bidding starts at a high price that continuously declines until one of the bidders stops the process by acquiring the object). Moreover, auctions for single indivisible objects are distinct from auctions for multiple objects. When selling multiple units of products or different types of objects, several possible auction designs are available. For example, a multiple-object auction format might allow for bids on combinations of items simultaneously (combinatorial auctions) or assets might be sold sequentially (Menezes & Monteiro, 2005).

Of course, it should be noted that to do well in an auction setting requires a strategy, because auctions “involve direct competition among prospective buyers for the right to purchase a product” (Häubl & Leszczyc, 2019, p. 1294). Usually, the right to acquire the auctioned object will be distributed to the person that values it most, and therefore is willing (is capable and wants) to pay more to win the auction and buy it (Hatzis, 2011). Bidding based on emotion or excitement may lead to overpaying and regret. This phenomenon—of winning the auction but then regretting it—is known as the winner’s curse.

The most familiar auction is where an item is put up for sale and the higher bidder wins. At Sotheby’s, it is a painting or an antique, on Google an ad position next to keyword searches, in Australia, houses, and in Tokyo... tunas. At the end of the 19<sup>th</sup> century, auctions spread in countries like Germany and Japan because an open-market operation was required to establish a price that would reflect current and prospective demand and supply conditions, and thus eliminate the price-depressing tactics of the distributor-buyers (Cassady, 1967). The last decades things have changed, with online auctions becoming more and more popular—and auctions in general becoming even more democratic. The common denominator is that there is one seller and many buyers who compete against each other to gain the desirable object (Dixit & Nalebuff, 2008). In other words, sellers can use auctions to determine the selling price and the winners of an auction (forward auction). Buyers can also use auctions. In this case, their goal is to buy items from the seller who makes the lowest offer (reverse auction).

This thesis focuses on forward auctions. It begins with a brief overview of the evolution of auctions and then discusses the basic concepts of auction theory, the most common types of auction mechanisms, and bidding strategies.



## Chapter 1

### Auctions from a Historical Perspective

#### Auctioning in Ancient Civilizations

Auctions have been used since antiquity to sell various objects.<sup>1</sup> The use of auctions in the conduct of human affairs has ancient roots, and the various forms of auctions in current use account for hundreds of billions of dollars of trading every year. Although Cassady (1967) mentions that no general study on the historical basis of auctions has been conducted, the literature on this topic agrees that the first known historical reference to the auction process is traced back to the 5th century BC. The Greek historian Herodotus of Halicarnassus recorded that the Babylonians auctioned women of marriageable age, making women the first items up for bids (Mochón & Sáez, 2015). At these ancient auctions, potential brides were auctioned off to suitable families for marriage. According to Wolfstetter (1996), these auctions were unique because bidding sometimes started at a negative price. Auctions were used in some societies to sell slaves, as well; a practice that was also widespread in the antebellum South of the United States (Hubbard & Paarsch, 2015). Moreover, the Romans held auctions in commercial trade, to liquidate property in times of financial straits, and to distribute plundered war booty, which were auctioned under a spear stuck in the ground (Cassady, 1967). From this practice comes the term that is used in Italian to refer to auctions, *asta*, which means “spear”, coming from the Latin *sub hasta*, meaning “under the spear”. In essence, as Krishna (2010) explains, the word “auction” derives from the Latin *augere*, which means “to increase” (or “to augment”, “to raise”), via the participle *auctus* (“increasing”), which is indicative of the pricing rule used in the traditional ascending auctions.

One of the most notable auctions was held in 193 AD, when the Roman Empire was sold at auction. The conflict between Emperor Pertinax and the Praetorian Guard led to the emperor’s assassination. Having killed the reigning emperor, the Praetorians proceeded in a bold move: to sell off the entire Roman Empire by means of an auction. So, the guards put the whole empire up for auction and they announced they would

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<sup>1</sup> To explore the history of auctions, see also Shubik, M. (1983). Auctions, bidding, and markets: An historical sketch. In R. Engelbrecht-Wiggans, M. Shubik, and R. M. Stark (Eds.), *Auctions, bidding, and contracting: Uses and theory (Studies in game theory and mathematical economics)* (pp. 33–52). New York, NY: New York University Press.

appoint the highest bidder as the next emperor (Wolfstetter, 1996). The imperial title was won by the wealthy senator Didius Julianus who outbid his competitors by promising 25,000 sesterces [or 6,250 drachmas, according to Cassady (1967)] per man to the Guard. The winner was then declared emperor but lasted for only two months “before suffering from what is perhaps the earliest and most extreme instance of the ‘winner’s curse’: He was beheaded” by Septimius Severus who seized power (Krishna, 2010, p. 1).

Unfortunately, not much is known about auctioning in other ancient civilizations. In China, auction sales were one of the four institutions used to raise money for Buddhist temples, along with pawnshops, mutual financing associations, and lotteries. Personal belongings of deceased monks appear to have been auctioned off since the 7<sup>th</sup> century AD. As Cassady (1967) describes, the monk who acted as the auctioneer needed to know the normal price of the item and reveal to the bidders if it was new, old, or worn out. If bidding went too high, he reminded his fellow monks: “Better be thoughtful. You might regret it later”—something that, even today, participants in auctions should always keep in mind in order to bid carefully and not be overzealous with their bidding (Cassady, 1967, p. 29). Too much enthusiasm may lead to the winner’s curse.

### **Auctioning in England (17<sup>th</sup>-18<sup>th</sup> Century)**

However, after the fall of the Roman Empire and until the 17<sup>th</sup> century, the importance of auctions decreased, “primarily because of limited population concentrations and the poor circulation of currency”, observe Mochón and Sáez (2015, p. 2). Towards the end of the 1600s, sellers of paintings in England frequently met in popular public places like taverns and coffeehouses to auction their goods and, during these sales, catalogs were often issued (Cassady, 1967). Certain types of tangible property, such as ships, were also sold using the auction method. The oldest legal action developing from an auction of any kind seems to have been *Daniel v. Adams* in 1764, notes Cassady (1967), a case where an agent was authorized to sell an estate by auction, but the contract had been made without the wife’s—who was the owner of the property—authority.

The oldest auction house is Stockholm Auction House (*Stockholms Auktionsverk*). It was founded in 1674 by Baron Claes Rålamb and is still in operation (Kenton, 2018). In the second half of the 18<sup>th</sup> century, auction houses—the companies that run the auction, facilitating the buying and selling of assets—began to specialize by market. Art and antiques is the market with the strongest tradition in auctions, for which the

main auction houses remain Christie's, based in London, and Sotheby's, based in New York, even if both were founded in London in 1766 and 1744, respectively.

Concerning the methods of auctioning, it seems like the conditions of sale in early-day England were similar to the typical ones today. Figure 1 shows a list of eighteenth-century operating rules, indicating the type of auction employed and its terms of sale:

1. The high bidder is the buyer and, if any dispute arises as to which bid is the highest, the goods will be put up for sale again.
2. No bidder may advance another's bid by less than sixpence when the amount offered is less than £1, or by less than one shilling when the price is £1 or more.
3. The merchandise for sale is warranted as perfect, and before removing the goods from the premises any buyer may accept or reject them.
4. Each buyer must give his name and make a deposit of 5 shillings on each pound sterling (if demanded); no deliveries will be made during the sale.
5. All purchases must be taken away at the buyer's expense, and the amount due must be paid at the place of sale within three days after the purchase.
6. Any would-be buyer who is unable to attend the sale may have his commission executed by a representative of the auction firm.<sup>12</sup>

**Figure 1** *18<sup>th</sup>-century operating rules* [Source: Cassady, 1967, p. 31. <sup>12</sup>Adapted from the original, as given in James Brough's *Auction!* (Indianapolis and New York: Bobbs-Merrill, 1963), pp. 66-67.]

From the wording used in the list above ("No bidder may *advance* another's bid"), we can assume that certainly some sales in the 18<sup>th</sup> century were conducted in a manner similar to the English auction system, which is prevalent today. Nevertheless, this list cannot serve as evidence that each and every auction employed such an ascending system. Another source, a seventeenth-century catalog, mentioned a "Method of Sale not hitherto used in England" called "mineing" which followed a descending system (Cassady, 1967). This method must have originated in Holland because it has the characteristics of a Dutch (descending) auction: the auctioneer put up each lot at a high price and kept reducing the price until a bidder called "Mine!".

### **Auctioning in Early-Day America (17<sup>th</sup>-19<sup>th</sup> Century)**

As institutions and ideas emigrate along with the people who move from one country to another, “the auction found its way from England to America” (Cassady, 1967, p. 33). This method of selling was used by colonists to dispose of property under the judicial process and to close out stocks of merchandise. Auctioning in early-day America was widespread. Auctions apparently used the ascending-bid system and took place in order to sell second-hand household furnishings, domestic animals, and farm utensils, to liquidate capital goods, and even to unload unsalable merchandise remaining in the importers’ inventory at the end of the season (Cassady, 1967). The auction system had various commercial effects in America. For example, auctions facilitated the introduction of foreign and new domestic products, and gradually the prejudice against the promotion of foreign goods was overcome. Moreover, small domestic manufacturers could gain a position in the market more easily. Imported items would also be directly available to inland markets as retailers from the interior regions of the United States increasingly patronized auction sales in the port cities of the East Coast (Cassady, 1967).

Any historical overview of auctioning practices would be incomplete without mentioning the infamous legal sale of slaves. Slave trade began in the Americas in the early 1600s, with Africans being transshipped to the Caribbean islands and to North America (McInnis, 2011). Slaves were used to labor in the production of agricultural products and as servants, but enslaved women were expected also to perform physical, sexual, and reproductive labor (Cassady, 1967; McInnis, 2011). These female slaves were used as sexual objects as their sexuality and reproduction was being commodified and exploited by their owners.

Slaves were treated as the chattel (personal property) of the owner and were bought and sold as commodities, usually in auctions. Occasionally, they were bought at a fixed price set by the vendor or after individual negotiation between the seller and the buyer (Cassady, 1967). African and African American (those born in the New World) slaves worked mainly on the tobacco, cotton, sugar, rice, and indigo plantations particularly in the Old South (Confederate States) of the United States (Hellie, 2018). A slave’s price varied, depending on inflation rates, demand and supply, and the characteristics of the slave. Factors such as sex, age, and physical condition affected the demand and price for slaves. Young, healthy, and tall male slaves were the most valued, as their

height was correlated with fitness and productivity, and they still had a considerable life-span (Cassady, 1967). On the other hand, “fancy girls” were the attractive black women who “brought more money at auction than the most skilled male slaves”, writes McInnis (2011, p. 139), because, in addition to serving as laborers, they would bear children, producing therefore more slaves. Risk factors were also reflected in the price of slaves. Thus, if a slave had a history of fights or escapes, the price was lowered because buyers risked the repeating of such behavior (McInnis, 2011). Similarly, a large number of injuries would be regarded as evidence of laziness or rebelliousness—and not as a sign of the previous master’s cruelty. Slaves were undressed during the auctions so that their backs could be inspected for whipping scars by the potential buyers. “Traders and buyers thought that they could read a slave’s history and his character from the scars” (McInnis, 2011, p. 129), so the value of a slave was affected negatively by the presence of such scars.

Generally, the slave-auctioning process followed the English method of ascending bids, as available descriptions suggest. The auctioneer made use of “the practice of displaying the ‘merchandise,’ even at the cost of embarrassing the individual up for sale” while the crowd in the marketplace engaged in mockery or cheering, describes Cassady (1967, p. 35). After the auctioneer’s opening speech, the first lot, consisting of one person or even a whole family, was put up for sale. Concerning family groups, the bidding was based on average price per person. To illustrate this, the example presented in Cassady (1967) will be used:

The value placed on the father might be \$1,200 and that on the mother \$950, and three children might be valued at \$725, \$650, and \$475, for a total estimated family value of \$4,000. This method of selling multiple units, not uncommon today, was undoubtedly adopted because it was expected to maximize returns. Not only did it emphasize the smaller individual figures instead of the larger total amount, but it placed the “value of the best slave in the group... uppermost in the bidder’s mind”. (p. 36)

The auctioneer would then suggest an opening bid and would lead the buyers upward. However, the starting price would sometimes be reduced in order to obtain a firm offer from the audience. It was also a common occurrence that “lots were withdrawn from the sale when bids were considered unreasonably low” (Cassady, 1967, p. 36). Slavery

and slave auctioning are a dark page in American history. These practices continued to be both legal and prevalent for many centuries until the American Civil War (1861-1865), when the Thirteenth Amendment to the Constitution of the United States of America abolished slavery in 1865 (Hellie, 2018).

### **Auctioning Today**

The practice of auctioning is relatively new in many areas and fields of commerce. In the Netherlands, Germany, and Japan, distributors controlled the producers until the end of the 19<sup>th</sup> century and until the end of the World War II in Hong Kong. Concerning the sale of fruits and vegetables in the Netherlands before the widespread use of auctions, produce dealers would buy directly from the grower, acquire goods on commission, or make advances to the producer for crops still in the ground; practices which often placed the grower at a disadvantage in relation to the dealer (Cassady, 1967). In Germany, either fishermen sold their catches themselves or middlemen were responsible for the selling. However, although a system of firm contracts between fishermen and distributors existed, the sale of fish by private treaty was unsatisfactory. Similarly, the auction became an effective tool in implementing a program of market reform in Japan and Hong Kong during the 20<sup>th</sup> century. As Cassady (1967) highlights: “The key to equitable treatment of producers by distributors is an open-market system, such as the auction, which permits buyers to sell their goods at market prices and thus prevents exploitation by distribution-buyers” (p. 39). This is why producers confronted the issue of distributor-dominating selling of horticultural produce and fish by establishing the sale of their products via auctions where they could sell their merchandise to dealers or consumers on a competitive-bid basis. Fishermen and farmers were no longer financially obligated to the distributors who paid them enough just to keep supplies flowing. Therefore, auctions serve both as an economic and a social instrument, argues Cassady (1967), as they foster competition among suppliers and enable producers to obtain the full market price for the goods they produce.

It is expected therefore that auctions are seemingly pervasive today: this institution is used to sell a variety of agricultural commodities and natural resources, as well as fine art, collectible items, real estate, and used cars. Additionally, firms and governments are aware of the advantages of auction mechanisms to allocate and set selling prices in environments of uncertainty, and extensively use the auction format of sealed-bid tenders to procure a variety of goods and services like weapons systems and tree-

planting services (Hubbard & Paarsch, 2015). All in all, Milgrom and Weber (1982) celebrate the fact that “The use of auctions in the conduct of human affairs has ancient roots, and the various forms of auctions in current use account for hundreds of billions of dollars of trading every year” (p. 1117). In recent years, auctions have observed strong growth, fueled largely by the advance of the Internet. Because the Internet eliminates barriers (both temporal and geographic) and reduces transaction costs—the cost incurred in making an economic exchange—it has emerged as the ideal channel to connect, directly and globally, supply and demand for any item (Mochón & Sáez, 2015). The web’s strong penetration into the field of auctions is demonstrated by the growth of companies dedicated exclusively to conducting online auctions, with the Internet auction house eBay (initially named AuctionWeb) being the paradigmatic example of a company that, since 1995, relies on the Internet to auction (almost) all types of items. For instance, some types of products which are completely banned are living wildlife items, narcotics, and fireworks.<sup>2</sup>

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<sup>2</sup> For the complete list of prohibited and restricted items on eBay, see <https://www.ebay.com/help/policies/prohibited-restricted-items/prohibited-restricted-items?id=4207>

## Chapter 2

### Auction Theory Basics

To understand bidders' behavior in an auction, it is essential firstly to introduce some basic terms, as presented in Dixit and Nalebuff (2008), Hendricks and Porter (2007), Hubbard and Paarsch (2015), Krishna (2010), Mochón and Sáez (2015), and Wolfstetter (1996). The value is the maximum price that a bidder is willing to pay for an item. A bid is the offer the bidder submits for an item and the bidder can follow three basic strategies: sincere bidding (bidders make a bid equal to their valuation), underbidding (bidders make a bid below their valuation), and overbidding (bidders make a bid above their valuation and usually experience a winner's curse). The highest bid made by any bidder represents the winning bid. However, the price of the highest bid and the selling price may not be equal. The selling price is the final price that the bidder actually pays for the item awarded and depends on the pricing rule that the seller (e.g. the auction house) establishes. As will be illustrated below, only under the first-price rule the bid submitted by the winner is equal to the price the buyer will eventually pay to acquire the item for sale. Depending on the type of the auction used, the participants can continue bidding until the price equals their valuation (ascending auction) or make directly a bid equal to their valuation (sealed-bid auction).

In single-unit auctions, the income of the bidder is equal to the bidder's value of the item obtained while the surplus of the bidder (profit) is equal to the difference between income (value) and cost (price to be paid by the winner). Obviously, the greater the difference between the value and the selling price, the greater will be the surplus for the buyer and this is exactly what participants in auctions aim at achieving: buying an object they highly value at the lowest possible cost (i.e. paying less than how much they actually value the item). The seller's revenue in a single-unit auction is equal to the price paid by the winning bidder, according to the pricing rule being followed, and, in multi-unit auctions, it is the sum of the prices paid by all winning bidders.

In terms of contract law, according to Fried (2016), the offeror in the case of an auction is not the auctioneer who introduces the bids, but it is actually the bidder. After all, bid is another word for offer and the auctioneer is inviting offers from the audience members who are interested in acquiring the item in question. Then, when the auctioneer gets a second offer, the first offer is rejected and the first bidder is free of



that first offer. Bidders can bid again or walk away having reached their value. Only when there is not any better offer from the bidders there is acceptance by the offeree, namely the auctioneer or the seller, and the final offeror is contracted to buy the product being auctioned. This means that, at the end of an auction, there is offer, acceptance, and a contract made.

One of the risks sellers face in auctions is that the selling price might not be attractive enough or satisfactory to them. To avoid this situation, the seller can set a reserve price. This is the minimum price for which the seller is willing to sell the item. This way, if the final selling price is below the minimum acceptable price, the seller is not obliged to make the sale. There is a main complication that arises with setting a reserve price, as Mochón and Sáez (2015) explain. The seller has to decide whether the reserve price will be revealed (public) or kept secret (private). If the seller sets a private reserve price, bidders may know or may not know that there is a reserve price. However, if the seller sets a public reserve price, the starting bid will be the reserve price to ensure that, at least, the reserve price will be met. Another alternative to avoid selling the item for a low price without setting a reserve price is for the seller to do shill bids. This way, the seller bids on the auctions' own items through multiple identities or with the help of family members and friends to artificially increase the price and avoid a final price that is lower than desired. However, shill bid, also known as bid padding, is prohibited in most auction settings.

With regards to the bidders' values, there are situations in which bidders do not have a clear value of the items but only an estimate. Of course, before the auction, bidders only know their personal estimate. According to auction theory, three bidders' types or preference structures can be identified: private value, interdependent value, and common value. Private value is influenced by personal and emotional aspects because an item is purchased for personal use or has a sentimental value. So, even if bidders knew the values of the other bidders, this information would not change their private value. In other words, knowing someone else's value can provide the bidders with a strategic advantage in how to bid at the auction, but the intrinsic worth of the object to them is probably unchanged by this revelation. Auction researchers refer to economic environments like this as the Independent Private-Values (IPV) paradigm. Nevertheless, it is possible that the information on the valuations of the other bidders during an auction may affect a bidder's own value, if the bidder observes signals about

the rivals' estimates—which is private information—through their bids (interdependent value). For example, bidders may increase their value of an item if they can resell it and obtain profits from a product that otherwise was of no value to them. Finally, common value is an extreme case of interdependent value. Before the auction, the individuals have their own value of an item based on their estimates, but having complete information regarding the item being offered after the auction, all of the bidders end up having the same value. In other words, as Mochón and Sáez (2015) state, even if the participants had different values before the auction because of their different estimates, the value of the item became the same when uncertainty is eliminated.

Concerning participants' bidding strategies, the decision about which strategy to follow involves a trade-off between the probability of winning the item and the potential profits. As it can be easily inferred, a higher bid increases the odds of winning the item but decreases the potential profits. In contrast, a low bid decreases the chance of winning but allows for higher profits. The decision about which is the best bidding strategy given this uncertainty can be influenced by factors like budget constraints and the attitude toward risk of each bidder. Risk attitudes reflect bidders' preferences over potential outcomes and the winning bidder's payoff may depend upon personal preferences, the preferences of others, and the intrinsic qualities of the object being sold (Milgrom & Weber, 1982). A bidder may be risk averse, risk loving, or risk neutral. Faced with this dilemma, "risk-averse players bid more aggressively than risk-neutral ones because they prefer to increase the odds that they receive some payoff at the expense of the size of the payoff they receive" (Hubbard & Paarsch, 2015, p. 99). Hence, an individual with risk aversion would rather accept some lesser amount with certainty. Risk-averse bidders prefer to "secure" the prize, placing a higher bid to increase the chances of winning the item, even if this may reduce the surplus. In contrast, a risk lover will choose to make a low bid to seek greater potential profits. Finally, for risk-neutral bidders, the optimal bidding strategy is one that simply maximizes their expected surplus.

The pricing rule that is set by the auctioneer should be carefully considered by the bidders because the winning bid might not match the final, selling price and this information will affect expected surplus and bidding strategies. It has been found that when bidders are risk averse, "the first-price sealed-bid auction generates higher expected revenue for the seller than the ascending auction or the second-price sealed-

bid auction”, but when bidders are risk-neutral, “the second-price auction generates higher average prices than the Dutch and first-price auctions” (Milgrom & Weber, 1982, p. 1089; Mochón & Sáez, 2015, p. 18). Additionally, competitive interaction among bidders—an essential aspect of auctions—also influences bidders’ behavior. According to recent research and experiments conducted by Häubl and Leszczyc (2019) on the speed of competitor reaction among bidders in ascending auctions, “being outbid more quickly by other auction participants causes bidders to perceive an auction as more intensely competitive, resulting in a greater desire to win, and ultimately in a willingness to pay more for the auctioned product” (p. 1309).

Another crucial element of auctions is the concept of agency. For example, a collector of antique glass bottles cannot be present in an auction of 19<sup>th</sup>-century perfume bottles in another country. So, a potential deadweight loss looms as the collector misses out on something valuable while the seller misses out on a sale that could be made at a much better price to this potential bidder (Fried, 2016). Overall, this is a cost to society, generated by the economically inefficient allocation of resources within the market. In order to ensure the most satisfactory allocation of goods to the players who value them the most, a third party can be involved in the auction. This party is called an agent, somebody who is under contract, under an agreement, to act for another person, called the principal. The agent’s actions are like the collector’s and they bind. In other words, the agent acts on the principal’s behalf, the obligations the agent incurs are obligations incurred on behalf of the principal, and when the agent contracts, it is as if the principal contracted (Fisher, Ury, & Patton, 2011). As Susskind (2016) argues, agents are suitable for entrepreneurial negotiations because they lack any personal attachment with what is being negotiated. As a result, they are less emotional and can assert more clearly the given situation. Likewise, we could deduce that the use of agents for bidding in auctions may reduce the winner’s curse since agents are not disrupted by emotional factors. Such feelings can sometimes be counterproductive as they lead collectors to bid overenthusiastically and overvalue the item in sale. Agents are thus able to disassociate themselves from the goods being auctioned, bidding only according to the principal’s orders.

## Common Auction Types

In addition to their historical significance, auctions function as “a barometer of market prices for items that are exchanged”, especially when it is difficult to determine their actual price (Mochón & Sáez, 2015, p. 2). In this sense, auction prices can serve as a reference for both buyers and sellers for future transactions. This has encouraged various markets to rely on auctions as a method for distributing items, such as industrial equipment, fish, flowers, paintings, cars, and real estate. So, an auction can be defined by one of its central properties: as a market clearing mechanism used to equate demand and supply (Menezes & Monteiro, 2005). Other market mechanisms which allocate scarce resources include fixed price sales (as in a supermarket) or bargaining (as in the negotiated sale of a used car or in an Arab “souk” market) (Fried, 2016). Nevertheless, auctioning is more flexible than a fixed-price sale and perhaps less time consuming than negotiating a price. As Menezes and Monteiro (2005) highlight, another “particular characteristic of the auction is that the price formation process is explicit. That is, the rules that determine the final price are usually well-understood by all parties involved” (p. 9). Economists however consider auctions to be examples of games of asymmetric and incomplete information as some players know something that other players do not (Hubbard & Paarsch, 2015; McAfee & McMillan, 1987). For example, bidders know what an item is worth to them but not how their rivals value it.

With the development of auction theory and experimental research, more sophisticated auction designs have appeared in order to promote an efficient allocation of goods and services, while generating competitive revenues for the seller. However, there are four standard single-unit auction types: ascending (English), descending (Dutch), first-price sealed-bid (Pay-Your-Bid), and second-price sealed-bid (Vickrey), as seen in Tables 1 and 2. These will be discussed in more detail in the following sections. It should be briefly mentioned also that, according to the revenue equivalence theorem, “when the valuations are private and the game is symmetric, the seller makes the same amount of money on average whether the auction type is English, Vickrey, Dutch, or sealed-bid” (Dixit and Nalebuff, 2008).

**Table 1** Types of auctions

		Pricing rule	
		First-price	Second-price
Auction format	Open	Dutch; oral, descending-price	English; oral, ascending-price
	Sealed-bid	Pay-your-bid; first- price, sealed-bid	Vickrey; second- price, sealed-bid

**Table 1** *Types of auctions* (Source: Hubbard and Paarsch, 2015, p. 8.)

Oral	Seal-Bid
ascending price (English) descending price (Dutch)	second-price first-price

**Table 2** *The most popular auctions* (Source: Wolfstetter, 1996, p. 370.)

## Open Auction Format

The open auction format is one of the two auction formats and sometimes it is referred to as the oral or the open outcry format (Hubbard & Paarsch, 2015). According to this bidding rule, auctions are dynamic: they allow bidders to make multiple bids and some information is shown during the course of the auction since bidders reveal their interests via open bids as the auction progresses.

In other words, “a process of price discovery occurs”: bidders gain information about the valuations of their competitors, which reduces uncertainty and thus the effect of the winner’s curse (Mochón & Sáez, 2015, p. 12). Nevertheless, such dynamic, open auctions may become too long and complex, increasing the costs of the auction, a fact that may discourage the weakest bidders (those with the lowest valuations) from participating in such an auction.

## The English Auction

The most famous type of auction is known as the English or ascending auction. This auction is commonly used in the sales of used cars, rare paintings, and houses, to state a few objects. In this format, the auctioneer stands at the front of the room calling out

increasing bids. The seller sets a starting price (that is relatively low) and increases it in small increments until there is only one bidder interested in buying the object. Therefore, in the most common of the auction formats, bids are taking place in ascending order and goods are sold to the highest bidder. “If no bidder submits a higher bid, the (symbolic) hammer falls after the counted time expires and the bidder with the last, highest bid has purchased the item” (Berz, 2010). Frequently, a reserve price must be met, which is the lowest price at which the auctioneer will sell the goods. This price may or may not be revealed to the bidders (Sollish & John, 2007). It is important to highlight that in an ascending auction, the second-price rule is followed. The winner pays an amount equal to the second highest bid (plus the bid increment when applicable). Thus, “the item is sold to the person with the highest valuation and the seller receives a payment equal to the second highest valuation” (Dixit & Nalebuff, 2008).

There are different ways to implement an ascending-bid auction. When bidders increase the price, a format traditionally used by art and antiques auction houses and in electronic auctions, bidders send their bids in different rounds, indicating the price they are willing to pay for the item and the auction ends when a bidder submits a bid that exceeds any other (Mochón & Sáez, 2015). There is also a model in which the auctioneer increases the price from round to round, so that bidders can decide whether to bid at the current round or not, and prices may even increase continuously (ascending clock auction) with bidders deciding when to stop bidding.

The optimal bidding strategy here is to bid until the price exceeds your value and then drop out. Your value is your walkaway number: the highest price at which you still want to win the item, the maximum money you are willing to give. As Dixit and Nalebuff (2008) illustrate: “At a dollar more you would rather pass, and at a dollar less you are willing to pay the price, but just barely.” Menezes and Monteiro (2005) state several other aspects of auctioning that should be mentioned, such as “secret reserve prices, dummy bids (bids made by the seller or the auctioneer, perhaps without the knowledge of the bidders), and sometimes even the possibility of negotiation between the winner of the auction and the seller” (p. 10).

## **The Dutch Auction**

The descending auction is also known as the Dutch auction since it was the method used in the flower market in the town of Aalsmeer in the Netherlands, where the largest flower auction in the world takes place today (Hubbard & Paarsch, 2015). The Dutch auction, which is not commonly used in practice today, is the open descending price counterpart of the English auction (Krishna, 2010). However, in a Dutch auction, on the contrary to the English auction, the auction begins by calling out an extremely high price which is progressively lowered until some bidder claims the item. The starting price is high enough so that no bidder is likely interested in buying the object at that price. The interested party can shout “Stop!” or press a button that stops the automatic clock. The object is then sold to this bidder at that given price, so the winning bid sets the selling price (first-price rule).

Multiple units can be auctioned, as well. In this case, more bidders press the button as the price declines. So, the first winner takes the desired product and subsequent winners pay less for their items, since they stopped the clock later (Dixit & Nalebuff, 2008). When all the goods are sold, the bidding is over.

## **Sealed-Bid Auction Format**

As the name implies, in this closed format, auctions use a sealed bid and each bidder is allowed to bid only once, in a single round (single-round auctions). So, at sealed-bid auctions, buyers indicate how much they are willing to pay for the auctioning object by submitting a bid in secret to the auctioneer, traditionally in a sealed envelope (Hubbard & Paarsch, 2015). In sealed-bid auctions, both first-price and second-price, each bidder submits a bid without the knowledge of the bids made by others. The selling price is the highest bid in a first-price auction and the second highest bid in a second-price auction. Dixit and Nalebuff (2008) mention that, generally, there are two steps to the process: the requirements are established and then the sealed bids are opened. Because bidders can only submit one bid, they tender their bid knowing nothing about the bids submitted by their rivals, so they should bid their true value. When all the bids have been submitted by an announced time, the auctioneer evaluates them and awards the object to the bidder who has offered the highest bid, or, in the case of a service in a reverse auction, to the lowest qualified (offering the lowest price) bidder.

The main advantage of such auctions is that they are quick and easy to implement. On the other hand, single-round auctions may cut down the income of the seller if the bidders make low bids in an effort to avoid the winner's curse, since they are not aware of how much the other bidders value the same item (Mochón & Sáez, 2015).

### **The Pay-Your-Bid Auction**

At first-price sealed-bid auctions, the buyer pays the highest bid tendered. In other words, the price this bidder offered (Hubbard & Paarsch, 2015). All bidders simultaneously submit their bids in a single round without the possibility of subsequent amendment. When all bids are received, the seller determines the winner (the bidder who made the highest bid), and the winner pays an amount equal to his bid. This is why this format is also referred to as the "Pay-Your-Bid Auction" [or "Pay-What-You-Bid" (PWYB)], as mentioned by Mochón and Sáez (2015): the winning bidder is the one committing to pay the most for the item at auction.

### **The Vickrey Auction**

In contrast, at a second-price sealed-bid auction, the winning bidder pays the second highest bid presented. The second-price auction is also called "the Vickrey auction" in honor of the Nobel laureate William S. Vickrey who first analyzed this type of auction in the early 1960s and received the 1996 Nobel Prize in Economics. In this type of auctions, bids are sealed and the item is awarded to the highest bidder but at a price equal to the second highest bidder's price (Dixit & Nalebuff, 2008). To illustrate this better, if three bids are received, one for \$200, one for \$150, and one for \$90, the winner will be the one with the highest bid, the \$200 bidder, just like in any forward auction. However, the winner will only have to pay \$150, the price of the second highest bid, as it happens in English auctions, as well.

This difference in the pricing rules might seem negligible, but it generates important differences in the bidders' behavior. As Hubbard and Paarsch (2015) aptly put it: under Pay-Your-Bid pricing (first-price), "a bidder's own offer determines the payment required, while under the second-price rule, it is the offer made by a rival bidder that determines the payment of the winner" (p. 14).



## Other Types of Auctions

### The Japanese Auction

The Japanese auction is an ascending-bid clock auction. It starts with a low price for all bidders to bid and the price increases continuously like in English auctions. All of the bidders start with their hands raised or buttons pressed and the bidding goes up via a clock. So long as their hand is raised, bidders are in the bidding. Bidders can leave the auction when they are no longer interested in the item. However, once they drop out by lowering their hand, they are not allowed to bid again after dropping out, and the auction ends when only one bidder remains. Since bidders drop out after the price hits their value, the last person remaining is the one with the highest valuation and the price the winner pays will equal the second highest valuation.

The main advantage of Japanese auctions is that it is always clear how many bidders are active. So, every bidder knows exactly how many competitors there are and even the prices at which each drops out. On the contrary, in an English auction, someone wanting to participate can remain silent and then make a surprise entry late in the contest (Dixit & Nalebuff, 2008; Mochón & Sáez, 2015).

### The Procurement Auction

Auctions are a way not only to sell but also to buy items. A procurement auction is a market mechanism in which an object or a service desired by a buyer is communicated to the bidders who supply it (Jin & Junfang, 2015). Thus, it is a reverse auction: there is one buyer and many sellers, who aim at getting the buyer's business. It is expected therefore that this type of auction offers the buyer direct access to many competing suppliers at a relatively low search cost. This is why governments are currently the economic operators that most often resort to this type of auctions: in order to buy<sup>3</sup> items and services from the supplier offering the lowest price. Consequently, they are often referred to as low-price, sealed-bid auctions. A good illustration is a local government that wants to build a road. When such an auction takes place, the government takes bids to determine who will build it. In this case, the winning bidder, who wins the right to

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<sup>3</sup> It should be noted that governments do not only use auctions to buy but also to sell public assets. As Mochón and Sáez (2015) highlight, some of the public goods that have been allocated through auctions include radio spectrum licenses, CO2 emission rights, bonds, bus lines, electricity, and wood.

supply to the buyer, is the one who makes the lowest bid, as the buyer wants to obtain the infrastructure service as cheaply as possible.

However, reverse auctions are more complicated than forward auctions, because the bidders are “not using identical currencies”, as Dixit and Nalebuff (2008) state. In an English auction, for example, among \$40 and \$60 bids, the sellers know \$60 is a better bid, as they will receive more money for the object for sale. But in a procurement auction, this is not equally clear. The \$40 offer might be better than the \$60 offer for the buyer, since the buyer will pay less for the—presumably—same service, but the quality of work may be different in the case where the offer is lower. Nevertheless, the higher price may reflect devices like the reputation, trust, and reliability of the seller for prompt delivery, which may raise the price but eventually serve as cost-saving devices (Hatzis, 2011). Hence, the lowest bid is not necessarily the best one, because the buyer may have to spend afterwards more money, raising the total cost of the service provided. But if, for similar reasons, the lowest bid is not always going to be chosen, then the sellers do not know how low they need to bid in order to win the auctioned service. A solution would be to impose performance standards in the auctioned products, so that each and every service meets basic criteria and prices are not indicative of the quality of the service (Dixit and Nalebuff, 2008). However, such a measure cannot be easily implemented in practice.

### **The All-Pay Auction**

In this type of auctions, losing bidders pay, too. All-Pay auctions involve awarding the object to the highest bidder but also require payment from all bidders who participate (Hubbard & Paarsch, 2015). So, the difference between what the seller receives and what the winner pays is funded by the losing bidders. Usually, this auction type is used in internet auctions, often referred to as penny auctions. All-Pay auctions are also a valuable way of selling goods when bidders are interested in the amount of money generated at auction, for example at charity auctions. In this case, bidders who are supporters of a charity, are typically interested in both winning the object and raising money for an organization. They do not care only about their expected payoff concerning whether they win the object but also enjoy seeing the charity raise funds. Therefore, in this setting, the bidder with the lowest possible valuation does not get zero expected payoff but, in fact, earns a payoff that is linked to the amount of money raised by the charity. This may be related to the fact that researchers found that all-pay

auctions and bucket auctions<sup>4</sup> indeed generate more revenues for charities than winner-pay auctions.

### **The Multiple-Unit and Multiple-Object Auction**

When bidding for multiple objects or units, additional strategic considerations arise, as “an individual’s bid for one object might influence the allocation (price and likelihood of winning) not only of this particular object but also of other objects” (Menezes & Monteiro, 2005, p. 117). Unlike in single-object auctions where a bidder’s only concern is the bid of the opponent with the highest price, in a multi-object setting, bidders have to take into account several bids.

As Hubbard and Paarsch (2015) mention, there should be a distinction between two similar types of auctions: multi-unit auctions involve the sale of several units of the same object, while multi-object auctions involve the sale of several different objects. The objects and the units can be either packaged together or sold individually. As a consequence, if there are more than two objects for sale, they can be auctioned sequentially (consecutively in a sequential auction) or simultaneously (sell everything at the same time in a simultaneous auction) and bidders may demand one or more units. In short, concerning simultaneous auctions, there are two common types: discriminatory and uniform-price auctions. In the first type, winning bidders pay their bids. In the latter, all the winning bidders pay the same amount, either the highest or the lowest winning bid.

### **The Online Auction**

“One core lesson of auction theory”, as we read in Hubbard and Paarsch (2015), “is that the seller can expect higher prices for an object that bidders value privately when the number of bidders at the auction increases” (p. 147). This is reflected accurately in the online-auction setting. The emergence of the Internet made independent people become instantly connected to the rest of the world—or at least the part that has access to the Internet—and, by connecting bidders virtually, it expanded the number of potential bidders, thus allowing sellers to earn higher prices.

Concerning the bidding procedure, electronic auctions have some features in common with the four main types of auctions. For example, Internet auctions frequently have

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<sup>4</sup> For a detailed analysis of bucket auctions, see Hubbard and Paarsch, 2015, p. 104-105.

bid increments (the minimum amount that one bid must exceed another) and follow the first-price rule. However, at Internet auctions, bidding typically takes place using a procedure called proxy bidding, which is a unique characteristic of online auctioning. In this process, bidders report a number to a website server that represents their value: the most they are willing to pay for the item for sale at auction. This maximum price is unknown to rivals, but it permits the bidder to authorize the server to act on the bidder's behalf in order to bid up to the bidder's proxy (Dixit & Nalebuff, 2008; Hubbard & Paarsch, 2015). The main advantage of using proxy bidding is the fact that, because Internet auctions are typically conducted over days, the proxy removes the need of the bidder to monitor the auction closely, thus allowing the bidder to avoid associated transaction costs. The server acts as the bidder's agent, offering bids that exceed rival bids and notifying the bidder when the current price exceeds the authorized threshold.

The dominant Internet auction, eBay, epitomizes perhaps better than any other auction market the notion that auctions can be used to discover the price of unique objects. Some peculiar examples of things sold on eBay include the oldest known pair of Levi jeans for \$46,532, a piece of a meteorite for \$450,000, and the town of Albert, Texas for \$2.5 million. Other websites where electronic auctions take place are ShopGoodwill.com, PropertyRoom.com, GovSales.gov, uBid.com, eBid.net, Catawiki.com, and Artsy.net, while Quibids.com and DealDash.com offer penny auctions where there is a bid fee to participate. Such websites benefit both sellers and buyers, providing what economists refer to as network effects. "The value of the online marketplace is greater to an individual participant the more participants are involved" (Hubbard & Paarsch, 2015, p. 149). Thus, sellers benefit from a large number of buyers because competition increases average traded prices and buyers benefit from a large number of sellers making it more likely to find items that interest them. However, such network effects make it difficult for new online auction websites to enter the industry.

Trust, reliability, and reputation play a central role in every transaction where there is a high degree of uncertainty and asymmetric information, especially in auction environments, online trading, and in the market for used goods. With the anonymity the Internet offers, good sellers are indistinguishable from bad ones, suppressing prices reliable sellers should receive and would receive in a face-to-face transaction, and potentially compromising the ability of the market to function at all. For example, in the market for used cars, the presence of poor-quality vehicles ("lemons") hinders the

views and expectations of the potential buyer about the average car for sale (Hatzis, 2011). This is why participants in online marketplaces usually build their reputation via the opinions and ratings of those who have had prior experience with them. Sellers on eBay rely on their customers to convey to the other users their quality and credibility, just like it happens with most major players in today's "sharing economy" like Uber and AirBnB.

Finally, another significant consideration about online auctions is the opportunity to end an auction early at a prespecified price.<sup>5</sup> More specifically, sellers can put objects up for auction along with a posted fixed price, referred to as the Buy-It-Now (BIN) price, an option that has been available on eBay auctions since 2000. However, once a bid has been tendered, the Buy-It-Now opportunity is no longer active and the sale continues according to the auction format, creating "a hybrid of auction and fixed-price mechanisms" (Hubbard & Paarsch, 2015, p. 176). This mechanism has several important implications for the sellers and the buyers, as Hubbard and Paarsch (2015) present. The Buy-It-Now option can be a way for sellers to receive prices that exceed what they would expect at a standard eBay auction when buyers are impatient or risk averse, because they are willing to pay a higher price to ensure winning the object rather than go through the risk that an auction involves. Briefer auctions may also increase bidder participation. Nevertheless, sellers could mistakenly underprice the object by setting a buy price that is too low, whereas some bidders may get entertainment or experiential value from participating at the auction and would be willing to pay a premium to participate.

Recently, a shift to posted prices has been detected. This fundamental change in consumer preferences and purchasing habits is directly linked with the fact that today time spent online has a higher opportunity cost and everything can be available instantaneously. As consumers are able to compare prices online easily, shoppers can immediately ensure they are getting a good deal (or at least not overpaying too much). So, they do not need to wait to see the price this object will be sold at in an auction. Instead, sellers who are using auctions expect lower prices, implying that bidders might

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<sup>5</sup> As mentioned in eBay's help center: "There are two ways to buy on eBay. With Buy It Now, you pay a fixed price and buy the item immediately, or you can bid on an item and try to win it for a lower price in an auction." For more information, visit <https://www.ebay.com/help/buying/buy-now/buy-now?id=4002>

get items at auction at bargain prices. Of course, consumer trends come and go, but what has been historically proven is that, even if the way auctions are conducted has changed dramatically over the years, the notion of a mechanism where consumers participate in establishing a fair price for goods and services is not likely to be abandoned so easily.

## Conclusion

As presented in this paper, auctions are a historically important economic mechanism. Simply put, auctions are a way of equating demand and supply. From auctions in ancient civilizations to online auctioning today, it seems like the concept of auctions is dynamic, evolving and transcending time and space.

Concerning some important aspects of auction theory, in auctions the item is usually awarded to the participant who made the highest bid. However, four types of auctions, and variants of them, make up the majority of auctions used in practice. They follow either the open or the sealed-bid format and a pricing rule set by the auctioneer (first-price or second-price rule). The two most commonly used auction formats are the English and the Dutch auction. The English or ascending-price auction is the best-known auction type. It is an open ascending-price auction where an auctioneer starts requesting bids at a low price which gradually augments and the participants bid by meeting the increments proposed by the auctioneer. The auction stops when no bidder is willing to increase the bidding above the highest standing bid. The bidder with the highest bid wins the auction and pays the second-highest bid, the selling price. On the other hand, the Dutch auction is an open descending-price auction. Bidding starts at a high price that continuously decreases on an automated clock. The auction ends when a bidder stops the clock. This bidder wins the object and pays the price at which the clock stopped. Other types of auctions discussed are pay-your-bid auctions, Vickrey auctions, Japanese auctions, procurement auctions, all-pay auctions, multiple-unit and multiple-object auctions, and online auctions.

To conclude, auctioning is found to be a beneficial market mechanism to the society and the economy, as it is regarded as a fair way to determine the price of various types of products. Although auction theory has various components, it is relatively easy to understand the basics of auctioning and participate in this competitive and entertaining game of buying and selling goods and services, that has been used since antiquity and will continue to be relevant in the future.

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