An Approach to Show and Repeat the Winner's Curse in Game Theory: The Cascade Effect in a Private Value Environment of B2B Auctions via the Beer Distribution Game

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ABSTRACT

Companies are forced within a competitive market environment to overstep their own calculatory limits running the risk of a *winner's curse* because not winning in a business-to-business (B2B) auction contest might cause adverse financial consequences like negative economies of-scale for the company or a lowering of the market share. To ease simulation in logistics, the Massachusetts Institute of Technology (MIT) developed in the 1970s the beer distribution game to show the bullwhip effect in logistics. On the basis of such a successful structural approach, the beer auction game was developed in post-doctoral research together with industrial players to show, analyze and easily repeat the cascade effect in combination with the winner's curse which shows the drop of margin in several steps up and into negative values due to future expectations of business. Additionally, it is demonstrated first time that the winner's curse can also take place in private-value and not only common-value auctions due to endogenous and exogenous probability costs.

KEYWORDS

game theory, winner's curse, auction, eauction, B2B

1 INTRODUCTION

The behavior of auction participants in general has been researched for many decades. Especially William Vickrey (who is name patron of the Vickrey auction type) deepened the understanding of the objectives and behavior of participants [1]. Moreover, Richard H. Thaler, John H. Kagel and Dan Levin deepened the understanding of the *winner's curse*; a phenomena that winners usually overestimate the value of the purchased good or the supply contract price in common-value auctions [2–4]. A less investigated field is the behavior of companies in the field of B2B business where companies are very price sensitive on purchaser side and margin sensitive on the supplier side and the calculations take place in a private-value environment. Generally speaking, a purchaser - all other aspects being equal - only has to the take lowest sales price offer into account. On the supplier side the quantity of parameters to be considered is much larger due to impacts on cost, market share, economies-of-scale, risk management, etc. Especially the *winner's curse* which results in a negative outcome for the winning company plays an important role in a bidding strategy. A strategically planned bidding approach might actually mean that one bidder provokes another bidder to overestimate the value and the most beneficial situation is actually not winning an auction in the end, whereas the winner has to suffer the negative consequences of the deal.

For decades and most likely centuries, companies have been using comparative price requests towards their suppliers to determine the market price of products to be purchased. With the increasing availability of information related to the number of players and the speed of data, the procurement process in B2B has

increased significantly in scope but reduced in time either using common or private market places including auction functionalities [5]. Two standard procedures can be observed in the market on a continuous basis. Either, larger companies invite their suppliers to regular, often yearly supply and price negotiations. Procurement managers identify their regular suppliers, split their demands in bulks and negotiate - often personally - with suppliers price adaptions. This approach gives procurement companies the possibility to rely on price and supply stability during the negotiated term of validity.

Or companies publish their required supplies based on arising needs for large quantities and request offers on the spot. Especially in a market where price downturns are to be expected, demand does not meet supply and an overcapacity exists in the market, such a methodology can assure continuous price competition towards the advantage of the purchaser with the possible exception of protected markets or oligopolies.

In both cases – for obvious reasons – the procuring responsible has to consider as well the reliability of suppliers regarding continuity, quality of products, service support and other general business processes. This article will not focus on that part of a business partner evaluation but assume that this has already taken place beforehand during the selection process of suitable suppliers and that all suppliers selected are suitable for taking up business. The only effect out of the business evaluation taken into consideration might be the assignment of a *bonus* or *malus* during the selection process that might affect the calculation of the winning bid during the financial evaluation. For both approaches negotiating prices either on a yearly basis or on the spot, auction principles can be used to determine the price itself. Especially originating in the automobile industry at the beginning of the 21st century, auction principles were used in real-time online environments to increase price-finding transparency. Ideally applied for C-goods which as pure commodities (usually in large quantities, lower price segments and easily described and compared technically between suppliers) the auction processes are also extended to B- and even A-goods as long as a detailed enough technical description can be provided to potential suppliers. Usually companies introducing auction methods into their procurement processes investigate and invest heavily into the required processes with the objective to optimize the price finding as much as possible to their advantage [6]. From a financial point of view, their internal price target setting will actually not change. Engineers design the product built out of components and design engineers together with technical procurement managers break down the target cost of the product into target cost for each component either manufactured in-house or supplied by an external manufacturer.

A manufacturer as a supplier on the other side holds much less experience since participation in auctions in comparison is still a more irregular event. Also compared to purchasers the calculation of auction bids during several rounds under time and competition pressure leaves room for errors and spontaneous decisions being the root cause for a *winner's curse.*

A standard game was developed to sharpen awareness for a complete calculation of cost, bidding and determination of exit strategies to avoid the *winner's curse*. This allows bidders to gain experience during auction rounds as well as collecting statistically relevant data for further academic research in a private-value auction where the own value is already known before the auction ends (contrary to a common-value auction that is defined as an auction in which the good auctioned carries the same value to every participant, although none may know exactly what this value is until the auction is over). Additionally the game permits to investigate bidding behavior when lowest or highest prices are announced in multi-round auctions, lowest price in Vickrey auctions or similar bidding circumstances.

The following theoretical section investigates and establishes the existence of the *winner's curse* in private-value auctions, which is not documented so far. The theoretical section afterwards concentrates on *cascade* effects taking place during multi-round bidding.

2 THEORY OF THE WINNER'S CURSE IN PRIVATE-VALUE AUCTIONS

A widely used variant in B2B auctioning is a sealed-bid multiple-round reverse English auction. This is described as manufacturers acting as bidders in order to offer their goods defined in quality and quantity over several rounds whereas in each round, the highest bidder is removed and in the last round, when only two bidders remain, the lowest bid wins.
Based on game theory it results in a Bayesian Game in which information about characteristics of the other players (particularly their cost calculation) is not complete [7]. At the same time – and depending on the specific market – it will lead to conditions set by a perfect market erasing profitability of all participants. In the absence of externalities, perfectly competitive equilibria are *pareto efficient*; no improvement in the utility of a bidder is possible without a worsening of the utility of some other bidder [4]. From a rational point of view, one would expect that bidders would lower their bids over both multiple rounds and multiple games and close in on the point of zero profit from above. Nevertheless, as was observed and can be reproduced in experimental games, bidders seem to suppress the priority of profitability and almost exclusively focus on winning the bids and the resulting turnover. Only later, they suffer the consequences of their bids with the *winner's curse*. In documented auction behavior, the *winner's curse* is usually related to common-value auctions meaning that to the bidder the real value of the good to be bid on is defined, but unknown until after the auction. In B2B auctions, it is a private-value auction since companies are able to calculate their cost position internally but still some endogenous and exogenous risk factors might blur the calculation to some extent. Additionally a high pressure to be successful in winning turnover might exist to maintain the market share of the company and consequently the winning bidders might ignore the informational consequences of winning in itself [2]. In order to visualize the effect of a private-value auction, the following constellation will be used which will then be repeated later in the beer auction game. It is e.g. to be assumed that 6 players $i = 1, 2, 3, 4, 5, 6$ are bidding in a sealed-bid multiple-round reverse English auction for the right to supply beer to a restaurant franchise in one country.
It is assumed that every player knows the cost of own production x_{pc}, and is able to put a calculatory value onto foreseeable, but in value and probability unpredictable endogenous x_{enc} and exogenous x_{exc} additional cost minus future internal economies-of-scale gains x_{exg} if the contract is won.
Every bidder therefore knows the calculation of its own cost C_i as

$$C_i = x_{pc} + x_{enc} + x_{exc} - x_{exg} \quad (1)$$

whereas value of the cost of competitors is unknown. It is bid on the value V of the supply contract whereas the value V is determined by the profit P calculated as

$$P = V - C \quad (2)$$

A bid should therefore be placed in the range of

$$Bi \in [C_i, \infty] \quad (3)$$

whereas ∞ is limited by the common market knowledge as the maximum C of the most inefficient participant plus a reasonable profit margin in the relevant industry.

In case of a multiple round reverse English auction whereas the highest bidder is removed

in each round (and the highest losing bid made known) ∞ is then replaced by $B_{il\text{-}1\text{-}y}$ to

$$B_i \in [C_i, B_{il\text{-}1\text{-}y}] \quad (4)$$

Since the highest bid Bil has failed to continue; $B_{il\text{-}1}$ as the second highest bid is the one to fail in the next round and has therefore to be underbid by the value of *y*.

The *winner's curse* is usually associated with common-value auctions because it is assumed that bidders in common-value auctions cannot assess the real value until after the bid. In a B2B auction based mostly in a private-auction environment (with some exogenous effects with common-value character) the bidders choose consciously to ignore or at least suppress them in order to be successful [3].

The moment, B_{il} falls below *C* the *winner's curse* begins to emerge although costs of x_{enc} + x_{exc} have not materialized, will not materialize immediately after the bid and may not materialize at all or only up to a certain probability percentage. From a rational point of view, the bidder would now either stop bidding or stop to lower the bid if he believed in his original calculation. If the bidder suppresses completely the originally calculated endogenous and exogenous risk factors the bidding would be within

$$B_i \in [x_{pc} - x_{exg}, B_{il\text{-}1\text{-}y}] \quad (5)$$

The potential value of the *winner's curse WC* can therefore be defined for the winner as

$$WC_i = B_{iw} - x_{pc} + x_{enc} + x_{exc} - x_{exg} \quad (6)$$

It can be assumed that the introduction of auctions in the supplier selection process has most likely the effect of changing a *positive sum game* to a *negative sum game* for the suppliers when the *winner's curse* materializes [8].

As a summary, the *winner's curse* also takes place in private-value auctions when bidders are supposed to know their own value of the result. But the pressure of trying to win the auction forces them to systematically suppress the risk. In the following section the *cascade* will visualize this phenomena.

3 THEORY OF THE *CASCADE* DURING MULTI-ROUND AUCTIONS

Especially in auction models like a sealed-bid reverse English auction running during several rounds and the most expensive one dropping out in each round until the lowest one remains, a *cascade effect* will occur during the bidding process.

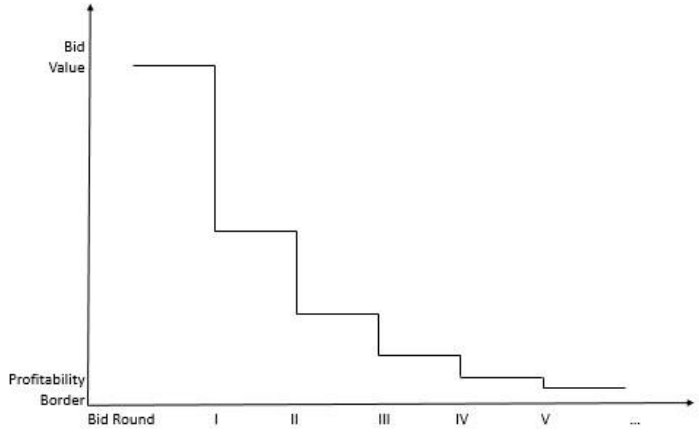

Figure 1. Cascade Effect

Contrary to the common approach in game theory for auctions to estimate the positive value of winning a bid is the negative value of its participants in a B2B auction, if suppliers cannot afford to lose one or several auction rounds because the company would remain with no turnover and suffer negative *economies-of-scale*. A calculation of an appropriate bid therefore not only calculates the direct Earnings before Interest and Taxes (EBIT) effects of the bid itself (which can be negative taking into account future *economies-of-scale* or the possibility that competitors

might disappear from the market) but on future positive effects on production costs [9].

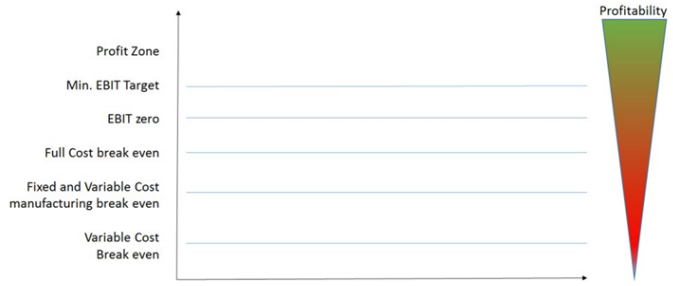

Figure 2. Different levels of lowest-price perspective

Also target setting for executives and the company itself has to be taken into account. What might be in the interest for individual executives or managers might not necessarily be in the interest of the company itself. Companies, when acting as suppliers in an auction procurement have to consider a multitude of variables, both endogenous as well as exogenous, to determine their bidding strategy and optimum price level [10]. The following overview shows a non-exhaustive list of parameters to consider:

Endogenous factors:

- manufacturing costs (including all factors up to full cost calculation)
- economies-of-scale
- importance of fixed cost coverage
- priority on market share
- priority on profit margin
- personal cost change over time (partially market driven)
- free production capacity
- investment requirements as specific production turnovers
- risk factors for unforeseeable costs (unexpected machine breakdowns, strike, …)

Exogenous factors:

- material cost change over time
- risk factors for unforeseeable costs (interruption of supply chains, loss of suppliers, force majeure, …)
- appearance of new competitors
- change in exchange rates
- business strategies of existing competitors

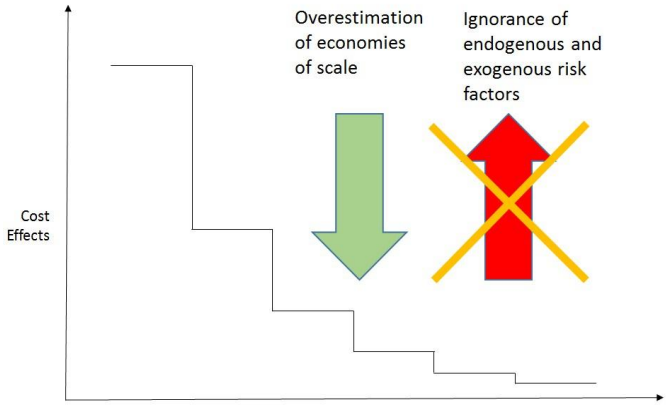

Figure 3. Risk Ignorance and 'polished' calculation

As any company strives for profit in the medium to long term, all these parameters have to be considered to come to a profitability calculation where - based on internal calculation and past experience of competitor markets prices – possible prices levels for an auction bid are determined. In a consistent calculation, this includes a full-cost evaluation combined with margin expectations and unexpected risk factors. Based on this result, an overview will be created which diversifies the calculation into different profitability zones depending on the profit objectives and the level of risk-taking preparedness of the company. For example, profit objectives vary greatly if additional contracts are sought just to fill up temporary free production capacity (at least variable cost breakeven) or if a major part of the business (e.g. key account) is negotiated (at least EBIT zero) [11]. Nevertheless, in preparation of auction scenarios, *war games* have to be played through several times in order to stay ahead of competitors. Depending on the auction modes like sealed-bid or non-publication of the value of the winning bid, a

correct but purely on endogenous factors based calculation might lead to an underestimation of business risks and an internal overestimation of cost savings effects [12]. In addition, desperation effects might occur – as happened when the telecoms infrastructure for Universal Mobile Telecommunications Systems (UMTS) was auctioned off by mobile operators per country in Europe – when the bidding strategy appeared not to be working and one share after the other was lost to competition. This forced the bidders to go lower and lower for the last bid to win anything at all whereas the required effects of economies-of-scale did not occur anymore due to too small shares overall.

4 METHODOLOGY OF THE GAME

A standardized game was designed to simulate B2B auction processes using multiple-round reversed English, Vickrey and Dutch auction to simulate different behavioral effects. In some auctions the first and the second winner are assigned shares according to their bidding price. The basic game is designed in a way that a European restaurant franchise auctions off separately the national supply of beer to the restaurants in six countries. Several breweries participate in the auction and for each brewery full costs, *economies-of-scale* and the profit objective are defined.

Endogenous and/or exogenous factors like risk probability estimation are included in the advanced version only (compared to the basic one) so the theoretical result in the basic version should be that all players starting with the same calculatory basis actually reach a perfectly competitive equilibria being *pareto efficient*. In the advanced version, the *winner's curse* can be simulated when endogenous and/or exogenous factors might or might not materialize and bidders go aggressively below their cost position.

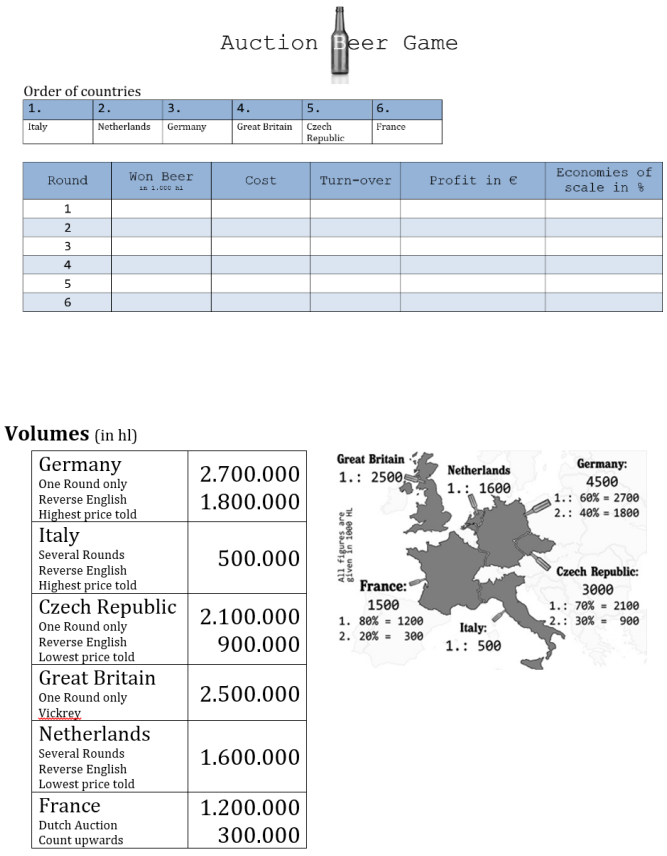

Figure 4. Beer Auction Game (game material can be requested)

The number of teams is dependent on the group of volunteers. It should be a minimum of three teams in order to be able to play multiple-round auctions where always the most expensive bidder is excluded after each round for one country. Two players per team assure that a discussed bidding strategy can be developed which leads then two a minimum of 6 players overall.

The players are not aware that everybody actually carries the same production and transport costs. To avoid passivity of the bidders each company team is told that their overall company profit is zero % EBIT with the present turnover running which keeps their company running and as CEOs they need to make their company more profitable. Their only opportunity to do so is to gain additional profitable market share whereas additional turnover also leads to *economies-of-scale*

overall. Players can skip countries but cannot enter with low bids in the beginning and raise later.

Teams are given half an hour to develop their personal bidding strategy. The purchaser acting as the moderator then leads through the game starting which the first country and the conditions set out e.g. with Great Britain, where it is only one Vickrey round, in which the lowest bidder wins and receives the price of the second lowest. Between countries, teams are given a quarter of an hour to discuss and revise their bidding strategy since for the teams not having won a country it was usually not expected.

When all countries have been auctioned, each team calculates its final financial status taking into account their additional turnover won and at which price.

5 RESULTS AND DISCUSSION

Typical pitfall of players in the beer auction game are:

- They do not catch quickly enough economies-of-scale and bid too high to win and are underbid by others significantly
- The profit calculation has to include the profit, which comes from the running turnover when economies-of-scale is applied. The effect here is underestimated because much more profit comes from there than from additional auctions
- The total achievable economies-of-scale percentage is not applied in the very beginning. The group who applies this already for the very first country, bids therefore aggressively and expects to win everything has the highest chance of winning
- Players understand that they have to move away from zero profit but misinterpret profit as obligation for the company instead of a personal target setting. Only one out of three company situations lets them survive as CEOs (positive profit) whereas the company itself survives in two out of three situations (positive and zero profit). CEOs tend therefore to gamble (and the company is worse off afterwards) to fulfil their objective

The effect for the *winner's curse* can be heightened by including special cards given either on purpose or randomly with carry endogenous or exogenous incidents like strike, fire, change of cost, with underlying or uncertain percentage probabilities. A major learning effect is that managing a company should not lead to risk taking beyond the reasonable for the company (not the individual). A bidder's bloodbath is often caused either when several bidders go in very aggressively with the same correct strategy or if a bidder calculates too conservatively, loses 1 or 2 auctions and is never able to gain a share but trying to.
Usually the result is that from 6 companies (making no profit, but also no losses) on average:

- 1-2 gain some low profit (0,1-2%)
- 1-2 did not win anything and continue at zero profit (they see this as bad but understand later that this actually might have rescued their company)
- 2-4 companies leave with a loss because they have won auctions but either with a price too low or that they would have needed several countries with such a low price (anticipated economies-of-scale) but did not get the countries they planned to acquire

Suppliers as companies have their dominating interest in the optimization of profit both as a percentage as well as turnover. Important to detect is that already in the first games played, the players might find themselves inside a

dilemma similar to the prisoners dilemma in game theory. Even experienced business managers tend to lose focus on the well-being of the company and only pursue their own objectives. Each semester business informatics students have the opportunity to participate in a B2B auction simulation lasting 6 hours. Students are giving pre-set cost factors with which they can calculate and determine their bidding strategy. Verbally the students are advised that managing a company is no lottery and they should not endanger the health of the company itself. This creates a conflict of interest, because at zero percent EBIT, the company is not directly in danger, but any move by the bidder will most likely have two outcomes: either the company becomes profitable or will make a loss where the company itself and not only the CEO is in danger. For example, repeatedly a game was played where the starting position of the company was making zero profit. From a company's perspective, although not desirable, this was preferable comparing to making losses. So the first two out of three situations (profit, zero, loss) were acceptable. From a CEO's perspective, only one out of three is acceptable (profit vs. zero or loss). In all cases, players sought to gain additional turnover via won auctions but in the end ignored profit limits too much and ended up with an actual loss combined with higher turnover. Hence the company was off worse than before.

Empirical results are not yet enough and need to be continued, but first conclusions can already been drawn. Some bidders have unintentionally avoided the *winner's curse* by underestimating the aggressiveness other their competing partners, having lost all bids and therefore as a company stayed at zero percent EBIT. Significantly, more than half of companies who have won some bids usually result in negative EBIT because calculations were too optimistic by not winning enough shares to drive down economies-of-scale and the few who actually ended with a positive result, moved from zero to one percent in all cases. A strong trend can be derived that in a zero sum situation all companies being equal – but not knowing about it – by striving for profit the strong tendency goes actually towards a negative sum situation and in the worst case actually nobody being on the profitable side.

6 LIMITATIONS

Practically no empirical evidence on B2B auction behavior exists since such auctions are usually performed under non-disclosure agreements (NDA) between suppliers and buyers. Also auctions are usually not standardized and therefore would only be difficult to be compared in a statistically relevant environment [5]. To improve this context, such a standardized game as the beer auction game should be played under similar conditions with professionals to draw further conclusions. Special attention has to be paid to the fact that over several rounds a learning effect might occur which impacts the *cascade* over time. This will lead most likely to a higher cost and risk awareness, avoid negative-sum games and limit to some extent the *winner's curse*. Also objectives of the suppliers and bidders have to be kept in mind in order to understand behavior better. Although it seems logical, that a buyer – all other things being equal – prefers to purchase from the supplier with the lowest price. But compared to a private consumer in a business-to-customer (B2C) context, a B2B purchaser has other consequential damages to keep in mind on the mid- to long-term radar as well. It might prevent the purchaser to start a ruinous bidder fight which might lead to a supplier reduction in the market and hence to higher prices in a oligopolistic or monopolistic supplier environment.

6 CONCLUSION

As discussed by Bell, Raiffa and Tversky it could make sense to distinguish three different approaches to theory in decision making when

uncertainty applies. Normative theories guide us how a rational actor should behave; descriptive theories show us how actors behave; prescriptive theories advice the actor how to behave when confronted with his own limitations [13]. In the case of B2B auctions, applying normative theories enable the bidder to create a rational bidding strategy taking into account all endogenous and exogenous factors when determining a profit making strategy.

In a perfect market the tendency goes to a zero sum game coming from above as positive sum games are nearing the zero point when increasing market information slowly eradicates positive sums for all players. Nevertheless introducing auction procedures in a perfect market could cause the risk to actually reverse such an effect. Then a zero sum market is not approached from a positive, but from a negative sum angle since bidders overestimate future market development and conditions falling prone to the *winner's curse* but cut out more sensible bidders short term by either obliging them to participate in a ruinous bidding behavior or lose significant parts of their market share.

A standardized game like the beer auction game does not only allow academic investigation of the subject at hand but also a more empirical approach inside the companies themselves. This should allow companies to understand better the negative effects of a *cascade* below the profitability line and what bidding strategies to use. Also how to combine better the objectives of a company overall vs. individual target setting at management or sales level which might endanger the company itself.

The *winner's curse* can therefore not only be found in common-value, but also private-value auctions in a B2B environment being visualized in a *cascade* adding knowledge to prescriptive theories about how to design best a winning strategy. The question remains if prescriptive theories are not hampered by the prisoner's dilemma itself; not every bidder might prepare himself with such theories; it might even be against antitrust law and companies usually act in self-interest. Any bidder is interested in the outcome of a high price. Unfortunately for the bidder the underlying wish to be cheaper than the competitor is the dominating factor.

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