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Auctions with Almost Common Values: The "Wallet Game" and its Applications

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Abstract

We use a classroom game, the "Wallet Game", to show that slight asymmetries between bidders can have very large effects on prices in standard ascending (i.e. English) auctions of common-values objects. Examples of small asymmetries are a small value advantage for one bidder or a small ownership of the object by one bidder. The effects of these asymmetries are greatly exarcabated by entry costs or bidding costs. We discuss applications to Airwaves Auctions and Takeover Battles including the Glaxo-Wellcome Merger. [82 words]

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1 Introduction

In most auctions in practice, there are at least slight asymmetries between bidders. For example, in a takeover battle the target company may have slightly more synergy with one potential acquirer than with another. Alternatively, one potential acquirer may already own a small stake in the company. Or one potential acquirer may have a reputation for aggressive bidding.

We will show that small asymmetries such as these can crucially affect who wins, and at what price, in standard ascending auctions for common-value objects. An apparently small advantage can greatly increase a bidder's probability of winning, and greatly reduce the price he pays when he wins, so these small asymmetries are also very bad news for sellers. Furthermore, the effects of these asymmetries are magnified by bidding costs or entry costs.

A common-value object is one that has the same actual value to each bidder, even though different bidders may have access to different information about what that actual value is. The most obvious examples are financial assets, but oilfields are another frequently cited example. A takeover target has a common value if the bidders are financial acquirers (e.g. LBO firms) who will follow similar management strategies if successful. The Personal Communications Spectrum (PCS) licenses sold by the U.S. Government in the 1995 "Airwaves Auction" probably also had very similar values to each of the telecommunications companies that were bidding for them, even though there was enormous uncertainty about what those values were.

However, although simple theory might treat all these examples as pure common values, in practice there are typically small asymmetries between bidders. We will refer to these auctions with small asymmetries as "*almost* common value" auctions, and will show that the distinction between pure common values and almost common values is critical.

The intuition is that giving a bidder a slight advantage, e.g. a slightly higher value when he wins, makes him bid a little more aggressively. While this direct effect may be small, there is a large indirect effect in an (almost) common-values auction. The bidder's competitors face an increased "winner's curse" (that is, it is more dangerous for them to win an auction against an opponent who is bidding more aggressively). So the competitors must bid more conservatively. So the advantaged bidder has a reduced winner's curse and can bid more aggressively still, and so on. In consequence, an apparently small edge for one bidder translates into a very large competitive advantage in an ascending common-values auction.

We begin in section 2 by discussing a classroom example, the "Wallet Game", which readers may wish to try in their own teaching, and then use it to explain some recent auction outcomes. Section 3 discusses the Airwaves Auction, Section 4 discusses takeover battles with "toeholds", and Section 5 discusses the 1995 Glaxo-Wellcome merger. These case studies suggest that "almost common values", that is, small asymmetries between bidders in an otherwise common value setting, can be disastrous for revenues in an ascending auction. So in section 6 we briefly discuss how a seller should run an "almost common values" sale. Section 7 concludes.

2 A Classroom Example: The Wallet Game

Select two students, and have each privately check how much money is in his or her wallet. Now announce that you will auction a prize equal to the combined contents of the wallets to these two students using a standard ascending (English) auction. That is, you will continuously raise the price until one of the students quits the bidding, and you will then pay the other student an amount equal to the combined contents of the wallets, in return for the student paying you that final price.[1]

Thus each student $i = 1, 2$ knows the amount t_i of money in his or her own wallet, and they are bidding for a prize of common value $v = t_1 + t_2$. How should the students bid?

It is easy to demonstrate that it is an equilibrium for each student i to remain in the bidding up to a price of $2t_i$: Given that the opponent follows the same strategy, a student who wins at price p knows that the actual value

[1]If these stakes are too large for comfort, restrict the exercise to only the low-denomination bills and coins in the wallets.

is $v = t_i + \frac{p}{2}$ which is greater than p iff $p < 2t_i$. So i is pleased to be a winner at any price up to $2t_i$, but would lose money if he "won" the auction at any higher price. In fact this is the unique symmetric equilibrium.[2]

Note that players take account of the *winner's curse* in this equilibrium. Conditional on the price having reached $2t_i$, i knows that the expected value of the prize exceeds the price, since j's signal is at least $\frac{p}{2}$ and so on average exceeds $\frac{p}{2}$. Yet bidder i must nevertheless quit, because i's concern is not with the expected value of j's signal, but rather with its expected value conditional on i winning, that is just $\frac{p}{2}$.

However the symmetric equilibrium is not the only equilibrium. For example, it is also an equilibrium for i to stay in the bidding up to a price of $10t_i$ while j quits at just $\frac{10}{9}t_j$. (If i wins at p, then $v = t_i + \frac{9p}{10} > p \Leftrightarrow p < 10t_i$ while if j wins at p then $v = t_j + \frac{p}{10} > p \Leftrightarrow p < \frac{10}{9}t_j$.[3]) In this equilibrium player i wins a very high fraction of the time, and at any given price at which he wins he finds more money in j's wallet, so he makes more money, than in the symmetric equilibrium. However player j wins much less often, and finds less money in i's wallet when he does win, so he is worse off, and the seller is also generally made much worse off.[4] Thus the pure common-value game has many equilibria which have very different properties. It should not therefore be a surprise that there are "almost common-value" games that are close to

[2]Note that this equilibrium is independent of the distribution of the signals, t_i and t_j, and does not require that the distributions be symmetric. (When we refer to this as the symmetric equilibrium, we mean only that the strategies are symmetric functions of the signals.) Nor is the equilibrium affected by risk-aversion.

[3]It is easy to construct a continuum of other asymmetric equilibria. To see why, assume that at price p bidder i will quit if $t_i \leq \underline{t}_i(p)$. The first-order condition for i is $\underline{t}_i(p) = p - \underline{t}_j(p)$ (because if $\underline{t}_i(p) < p - \underline{t}_j(p)$ then type $\underline{t}_i$ would lose money if j quits now so type $\underline{t}_i$ should have quit earlier, but if $\underline{t}_i(p) > p - \underline{t}_j(p)$ then type $\underline{t}_i$ would make money if j quits now so type $\underline{t}_i$ should stay in a little longer). Similarly the first-order condition for j is $\underline{t}_j(p) = p - \underline{t}_i(p)$. Since these first-order conditions are the same, they cannot uniquely determine $\underline{t}_i(p)$. Hence for any strictly increasing continuous functions $\phi_1(t_1)$ and $\phi_2(t_2)$, there is an equilibrium in which the marginal types who quit at any price satisfy $\phi_1(t_1) = \phi_2(t_2)$. See Milgrom (1981) (who first noted this multiplicity) for more details.

[4]Intuitively, the seller is worse off because player j usually loses quickly at a low price because each of j's types is bidding so much less. In this example, if the players' signals are both drawn from the same uniform distribution starting at zero, j loses 94% of the time and the seller's expected revenue is 20% lower than in the symmetric equilibrium. For general results about when the seller is made worse off, see Bulow and Klemperer (1996) and also Bulow and Klemperer (1997) who emphasise that there are, however, some cases in which the seller is not worse off.

this game and have equilibria that are close to very asymmetric equilibria of this game. (And the equilibria of these "almost common-value" games are often unique.)

In the following sections we will discuss applications to auctions that are almost common values; each can be illustrated by a tiny modification of the Wallet Game, but the outcome of each is very different from the symmetric equilibrium of the Wallet Game.

3 Small private value advantages: the Airwaves Auction

Consider the sale of the Los Angeles PCS license in the Airwaves Auction. While the license's value was very hard to estimate, it was probably worth very similar amounts to several bidders, except that one bidder, Pacific Telephone, had a small but distinct advantage. Pacific Telephone already had a database on potential local customers for the new services, its brand-name was already well known, and its executives were familiar with California.[5] The situation was thus well illustrated by the Wallet Game, with the small difference that if player 1 (representing Pacific Telephone) wins the auction he earns a small bonus prize.[6] (Player 2 receives no bonus for winning.)

How would a small bonus, say £1 in the Wallet Game, affect the bidding? The answer is that player 1 *always* wins in equilibrium. The intuition is clear. At any price at which player 2 wins the auction, player 1 would make more money than player 2 makes by winning, so if player 2 is willing to stay, then player 1 strictly prefers not to quit. Another way to see this is that since player 1 earns a £1 bonus by winning, player 1 will bid £1 more aggressively than before for any given behaviour of player 2, i.e. 1 bids as if his signal is $t_1+£1$. But this magnifies player 2's *winner's curse.* When 2 wins against 1 at any given price, 2 will find £1 less money in 1's wallet. So 2 must bid more

[5]Pacific Telephone also had no wireless properties prior to the auction, so had a strategic reason to enter the market as a hedge against its declining wireline business. There might also be other small economies of scope between the wireless and wireline businesses.

[6]Although many licenses were for sale simultaneously in the Airwaves Auction, the situation for a single license such as Los Angeles was very similar to that of the Wallet Game, i.e. a standard ascending auction for a single object.

cautiously, as if his signal is $t_2 - £1$. But this reduces 1's winner's curse. He will now find £1 more in 2's wallet at any given price at which 2 quits. So 1 actually bids £2 more aggressively, magnifying 2's winner's curse further, so 2 bids £2 more conservatively, etc. So in equilibrium 2 cannot bid beyond the amount in his own wallet, t_2. Player 1 always stays in until player 2 quits, and so always wins.[7],[8],[9]

What happened in the Airwaves Auction? Pacific Telephone indeed won the Los Angeles license, and at a price that most commentators thought was very low.[10],[11]

4 Small ownership advantages: Takeovers with Toeholds

Takeover battles are essentially ascending auctions and are often close to common values, especially when the contestants are "financial bidders" such

[7] This equilibrium (which was noted in Bikhchandani (1988)) corresponds to an extreme asymmetric equilibrium among those described in the previous section. Each of the equilibria described there (see note 3) can be obtained by allowing 1 to receive a private value "bonus" of $K\phi_1(t_1)$ contingent on winning, while 2 would receive $K\phi_2(t_2)$ contingent on winning, and then letting K be arbitrarily small. Furthermore in the modified game the equilibria are the unique perfect Bayesian equilibria if the t_i have finite support. Thus we have selected here the equilibrium obtained by taking $\phi_1(\cdot)$ arbitrarily large relative to $\phi_2(\cdot)$.

[8] A more formal way to see the result is to use iterated deletion of dominated strategies: if 1's maximum signal is $\bar{t}$, then 2 should never bid more than $t_2 + \bar{t}$ so, after eliminating strategies of 2 that bid more than this, 1's type $t_1 = \bar{t} - 1$ should stay in forever, so 2 should never bid more than $t_2 + \bar{t} - 1$, so 1's type $t_1 = \bar{t} - 2$ should stay in forever, etc.

[9] Avery and Kagel (1997) have experimentally investigated sealed-bid second-price auctions in this context. Since these auctions are strategically equivalent to ascending auctions (with two bidders) the equilibria are identical, although experimental subjects often respond differently to the two auction forms.

[10] The price for the single Los Angeles license was \$26 per head of population. Compare this with Chicago where two licenses were sold for \$31 per head of population. Yet most commentators thought LA's demographics were superior to Chicago's (Southern Californians are characterised as rich, loving new toys like portable phones, and spending much of their time stuck on highways with little else to do than phone), so that LA should have yielded the higher price.

Perhaps the surprise is that the Los Angeles price wasn't even worse than it was. One reason is that even bidders who know they are going to lose may have incentives to bid. Bidding may force the ultimate winner to pay more and so make him a weaker competitor in other auctions, and the Airwaves Auction rules meant that bidding on one license allowed you to delay "showing your hand" about which other licenses you might be interested in.

[11] A similar situation developed in New York, and its license was also sold rather cheaply (\$17 per head of population).

as LBO firms who would manage the target company in similar ways. However it is common for one or more bidders to have a small ownership stake, or "toehold", in the target prior to the auction. Assume initially just one bidder has such a toehold of (small) size θ. Then the situation is well modelled by the Wallet Game with the difference that player 1 (representing the toeholder) receives fraction θ of the wallets' sale price.

How would player 1 receiving a small fraction of the revenues affect the bidding in the Wallet Game? The answer, again, is that player 1 *always* wins in equilibrium. The reason is that player 1 has incentive to stay in the bidding a little longer than if he had no ownership stake, because doing so pushes up the price at which the wallets are sold.[12] This magnifies 2's winner's curse (2 will find less money in 1's wallet at any given winning price), so 2 must quit earlier, alleviating 1's winner's curse so 1 can bid yet more aggressively, etc. As in the case where 1 has a small private value advantage, if only 1 has a "toehold" then 2 cannot in equilibrium bid beyond his own signal, t_2, while player 1 stays in until 2 quits and player 1 always wins. Bulow, Huang and Klemperer (1997) show that even when both players have toeholds, the player with the larger toehold has a very substantial advantage even when both toeholds are arbitrarily small (though the player with the larger toehold does not always win).

In fact, there is substantial empirical evidence that ownership of a toehold increases a bidder's chance of winning a contested takeover battle, and also some evidence that having a toehold may reduce the price the winning bidder pays.[13]

The same point—that one bidder's small ownership advantage may both greatly increase that bidder's probability of winning, and also reduce the price he pays—also applies in other settings. One currently topical application is to the sale of "stranded assets" by public utilities. In these sales of assets that

[12]Absent an ownership stake, player 1 would quit where he would expect to make no profit as a winner at the current price. Bidding the price up ε further earns him fraction θ of the additional ε with probability close to 1, for small ε, but with small probability $o(\varepsilon)$ he "wins" the auction and so loses $(1-\theta)\varepsilon$. Since $\theta\varepsilon > (1-\theta)\varepsilon o(\varepsilon)$ for sufficiently small ε, for any θ, player 1 always bids a little more aggresively than without the ownership stake.

[13]See Walkling (1985), Betton and Eckbo (1995) and Bulow, Huang, and Klemperer (1997) for details.

are worth far less than book value, state public utilities commissions promise to reimburse utilities' shareholders a fraction $(1-\theta)$ of the difference between the asset's sale price and the book value, so the utility effectively has an ownership stake of θ of the auctioned asset.[14] Other applications include the sharing of profits in bidding rings, creditors' bidding in bankruptcy auctions, and the negotiation of a partnership's dissolution.[15]

5 Small bidding costs: the Glaxo-Wellcome Merger

In the preceding examples, if player 1 is known to have a higher actual value or to have the only ownership stake, player 2 never wins. More generally, e.g. if player 2 also has an ownership stake but a smaller one than 1's, or player 2 also has a private value but probably a smaller one than 1's,[16] player 2 wins rarely, and makes very little profit even when he does win.[17] Thus even small costs of bidding or of entering the auction will prevent player 2 from competing at all. In this case the final price may be even lower than in the preceding examples in which player 2 at least stayed in the bidding up to the price (t_2) that he knew the object was worth based only on his own information. Thus small entry or bidding costs can greatly exarcabate the effects of one player having a small advantage in an almost common value auction.

As an application, consider Glaxo's 1995 £9 billion takeover bid for the Wellcome drugs company (a takeover that created the world's largest drugs

[14] That is the utility is £θ better off if the asset is sold to someone else for £1 more, and is only £$(1-\theta)$ worse off if it must bid an extra £1 to win the auction, so the utility's position is strategically identical to owning fraction θ in our model.

[15] See Englebrecht-Wiggans (1994), Burkart (1995), and Cramton, Gibbons, and Klemperer (1987), respectively, for these three applications.

[16] Consider, for example, the model $v_1 = (1+\alpha_1)t_1 + t_2, \quad v_2 = t_1 + (1+\alpha_2)t_2$ where $\alpha_1 > \alpha_2$ so 1's private value component, $\alpha_1 t_1$, exceeds 2's, $\alpha_2 t_2$, unless 2 has a much higher signal than 1. See Bulow and Klemperer (1997) for discussion and analysis of this kind of model.

[17] Consider the profit 2 makes conditional on winning with $t_2 = \widehat{t}$, versus the profit 1 makes conditional on winning with $t_1 = \widehat{t}$. The marginal type of 2 that would have just won when in fact $t_2 = \widehat{t}$ wins, is typically higher than the marginal type of 1 that would have just won when in fact $t_1 = \widehat{t}$ wins (because 2 is bidding less aggressively, so his types are quitting faster as the price rises). So 2 makes lower informational rents on average than 1 does, that is, lower expected profits, conditional on winning.

group). It was probably generally believed that although the exact value was uncertain, Wellcome was worth broadly similar amounts to each of half a dozen major drugs companies, except that there were also particular synergies that made Wellcome worth a little more to Glaxo than to any other potential bidder. Thus the situation was probably that of the variant of the Wallet Game in which one bidder has a small private value advantage. However there were also bidding costs which were non-trivial (tens of £ millions) even though they were small compared with the stakes involved.[18]

What happened? After Glaxo's first £9 billion bid, Wellcome solicited higher counteroffers and received serious expressions of interest from two potential counterbidders: it was reported that Zeneca was prepared to offer about £10 billion if it could be sure of winning, while Roche was considering an £11 billion offer.[19] The difficulty was that neither of the potential bidders wished to enter an auction that they expected to lose.[20] And the result was that neither of them actually entered the bidding. So Wellcome was sold at the original £9 billion bid price, and its shareholders received literally billions of pounds less than they might have.[21]

6 How should you sell an Almost Common Value Object?

6.1 First-price auctions

The previous sections suggest that standard ascending auctions may be very unprofitable for sellers of almost common value objects, so what should sellers do instead?

[18]Glaxo's own fees were reported to be £30 million net of stamp duty.

[19]See *Financial Times* 8/3/95 p. 26, 27, 32. (To be precise, the potential bidders are described as "understood to be Zeneca", "thought to be Roche", etc.)

[20]This expectation had been reinforced by the fact that "Glaxo had let it be known that it would almost certainly top a rival bid". (*Financial Times* 8/3/95 p.32.) See our discussion of reputation effects in Section 7.

[21]Similarly, in the PCS Auction some potential bidders including MCI—one of the U.S.'s largest phone companies—failed to enter the auction at all. And there is evidence that "greater toeholds increase the probability of a successful single-bid contest by lowering both the chance of entry by a rival bidder and target management resistance" (Betton and Eckbo (1995)).

The most obvious answer is: use a first-price auction, that is, a "sealed-bid" auction in which each bidder independently makes a single "best and final offer" and the highest bidder wins the auction at the price he bid. In this auction format bidders have no opportunity to update their beliefs about their opponents or to condition their behaviour on their opponents' behaviour, so cannot follow strategies such as staying in forever until the opponent quits. So a small advantage for one player translates only to small changes in players' bidding strategies, and the equilibrium remains close to the first-price equilibrium of the original game.[22]Also, since even the weaker player therefore earns reasonable profits, small entry or bidding costs have almost no effect. Furthermore, it is a standard result that in the original game the first-price auction (as well as the symmetric equilibrium of the ascending auction) is seller-optimal under reasonable conditions.[23] So the first-price auction remains close to optimal when one player has a small advantage.[24]

This result may explain why first-price auctions are typically used in many almost-common-value settings such as the sale of oil leases.[25] However there are other factors that may make simple first-price auctions less attractive in

[22]The critical difference between first-price and ascending auctions is in the indirect, or "strategic", effect. With ascending auctions, bidding strategies are "strategic substitutes" (and very strongly so) in the terminology introduced by Bulow, Geanakoplos and Klemperer (1985), that is, when bidder 1 bids more, bidder 2 must bid less because conditional on winning at any price his revenue is lower. With first-price auctions, the indirect effect is ambiguous: when player 1 bids more, player 2 wants to bid *less* on the grounds that his marginal profit when he wins is lower, but *more* on the grounds that his probability of winning is lower so increasing his bid is less costly—when bidders' signals are uniform these effects cancel and the effect of player 1 bidding a little more is zero where the bidding ranges coincide. Thus the logic that when 1 bids a small amount more, 2 bids a similar amount less, so 1 bids an additional similar amount more, so 2 bids an additional similar amount less, etc., does not apply in first-price auctions.

[23]The conditions required are that the players' signals, t_i, are independently drawn from a common distribution, that the players are risk-neutral, that "marginal revenue is downward sloping ", and that the object must be sold (see Bulow and Klemperer (1996)). See Bulow and Klemperer (1997) for a detailed analysis of the reasonableness of these conditions.

[24]I do not know of any general theorem proving this. See Bulow, Huang and Klemperer (1997) for the case of small ownership advantages, and Avery and Kagel (1997) theorem 2.6 for an example with small private value advantages. See Milgrom (1997) section 2 proposition 9, and Bikhchandani (1988) for other related results.

[25]In addition to the effects we have discussed, oil-lease sales involve repeated interactions between bidders and so are also particularly vulnerable to the reputation effects discussed in Bikhchandani (1988). See section 7.

the takeover and PCS settings we have emphasised.[26]

6.2 How to Auction the Airwaves

In the Airwaves Auction many PCS licenses were sold using a simultaneous ascending auction.[27] This kind of auction facilitates the formation of efficient networks, because bidders can get some sense about whether they are likely winners on one license before committing too much money to buying related licenses. Furthermore, it is typically more likely in an ascending auction than in another type of auction that the bidder with the highest actual valuation wins, which is efficient.[28]

However, raising government revenue is also valuable in that it reduces the need for other taxes with their associated deadweight losses. So the deleterious effects of ascending auctions on seller revenues are important, and although pure first-price auctions would generate very little information to facilitate network formation, the following auction design might have captured many of the benefits of the design actually used without having its costs:

1. Run the actual auction used except allow 2 winners, i.e. "finalists", on each property. These finalists pay no money, but must compete in the next stage.

2. Allocate each property by a first-price auction in which only the 2

[26]Bulow and Klemperer (1997) show that rationing (as, for example in Initial Public Offerings) may be desirable with almost common values, because rationing reduces winners' curses by creating more winners (just as prices seemed to be lower in some regions where one PCS license was sold relative to many regions where two licenses were sold).

[27]Multiple licenses are open for bidding at the same time, and remain open as long as there is any bidding on any of them. There are also other rules including "activity" rules that specify minimum bidding rates that a bidder must satisfy to remain eligible to win licenses; these rules prevent the auction from taking too long.

The method was developed by McAfee, Milgrom and Wilson and, though we will criticise it below, it was probably the best among the many competing methods proposed at the time of the auction. For further details see the excellent expositions in McAfee and McMillan (1996) and, especially, Milgrom (1997).

[28]Efficiency was the stated objective of the auction.

finalists compete.[29] They must bid at least their final stage-1 bids.[30]

Note that running the second stage as a first-price auction overcomes the problems this paper has emphasised by giving weaker bidders a reason to enter and stay in the auction.[31] It is possible that using this mechanism even some of the stage-1 prices, let alone the ultimate prices, could have been higher than the prices actually achieved by the existing design.

Of course, the proposed design is constructed with the benefit of hindsight. It must also be emphasised that the optimal design choice for any future auction would also be affected by situation-specific details we have not discussed here.[32]

6.3 How to Sell a Company[33]

The potential problem with selling a company through a first-price auction is one of credibility: can management credibly commit to accept the highest bid and refuse to consider higher subsequent offers?[34] It may be legally

[29]If there are N identical (or almost identical) properties, allow $N+1$ finalists from stage 1 to compete in a sealed-bid stage 2 in which each of the N ultimate winners pays his own stage-2 bid. (For example, in the 1995 auction $N = 2$ in many regions. The highest sealed-bidder would choose first among the 2 licenses.) The design is most useful when the number of bidders with clear advantages is N.

[30]The order of the stage-2 allocation is probably not critical. It could, for example, be highest-priced stage-1 property first.

[31]In the actual auction some important potential bidders failed to enter the auction at all. See note 21.

[32]The proposed design also has the advantage of reducing the risk of bidders colluding. Furthermore, if bidders are risk-averse this increases its profitability relative to that of the design actually used. Finally, it also captures most of the benefits that an ascending auction captures when there is affiliation (see Milgrom and Weber (1982)). In general, it works badly only if (i) network effects are very important (there is a greater risk of complementary properties being won by different bidders under this design) *and* resale markets are very inefficient, or (ii) government revenue is much less important than allocating the licenses to the highest-value users *and* resale markets are very inefficient. However, the existing design now has the advantage of having been tested and refined in practice, and the problems discussed in this paper may be mitigated by an appropriate choice of the numbers and sizes of the licenses to be auctioned.

Some additional issues about the design are discussed in Bulow and Klemperer (1997).

[33]Obviously, space permits only the briefest analysis, focusing on avoiding the problems pointed out in this paper.

[34]Although the expected value of the winning first-price bid exceeds the expected price from an ascending auction in our context, the actual winning first-price bid will typically be below the runner-up's willingness to pay after the runner-up has observed that bid, in which case the runner-up may be willing to make another bid. See Burrough and Helyar (1990) for an amusing account of the takeover battle for RJR Nabisco which included

difficult to do so, and directors may also be very reluctant to face a possible stockholder law suit asking why they are refusing to consider higher offers.

One way around the credibility problem may be to run a first-price auction and award the winner a "break-up fee",[35] options to buy stock, or options to purchase some of the company's divisions on favourable terms; this may make it unprofitable for any other bidder to enter a higher subsequent bid. Thus our analysis can justify the use of "lock-up" provisions to support the credibility of a first-price auction.

If running a first-price auction is too difficult (e.g. lock-up provisions may themselves be legally vulnerable), a second strategy is to try to "level the playing field" between unequal bidders by, e.g., selling a small ownership stake, or equivalently options, to the weaker bidder so that the bidders can compete on more equal terms in a standard ascending auction.[36] Finally, it may be possible to directly compensate a second bidder for entering an auction, or for competing more aggressively in it.[37] Thus our analysis can justify offering inducements to a "white-knight" to enter the bidding.[38],[39]

7 Conclusion

We have shown that the outcomes of standard auctions are highly sensitive to small asymmetries between bidders in (almost) common value settings. We have emphasised small value advantages, small ownership shares, and small

several successive supposedly-final first-price auctions for the company.

[35]This is a fee that is payable to the winner of the first auction in the event that it does not ultimately win the company.

[36]See Bulow, Huang and Klemperer (1997) for further analysis of this possibility. Note that having options with an exercise price below the current bidding level is strategically equivalent to having a small ownership stake.

[37]For example, Bell South was paid $54 million for entering the takeover battle for LIN Broadcasting in competition with Craig McCaw. (See *Economist* 15/6/96, p.83.)

[38]Of course the favoured white knight must be the weaker bidder.

[39]Why, then, did Wellcome offer no inducements to another potential bidder to compete with Glaxo (including the possibility of accepting the "lock-up" bid of about £10 billion that Zeneca is thought to have offered)? In this case it may not have been legally possible. In particular, Wellcome's largest shareholder (the Wellcome Trust) had obtained Glaxo's original bid in return for an undertaking not to encourage another bidder (though the Wellcome Trust retained the ability to accept a higher offer). See *Financial Times* 8/3/95, p.32. Thus with almost common values, committing to an ascending auction may make it easier to obtain the original offer that puts a company into play, at the expense of obtaining the best price for the company after the first bid has been made.

entry costs, but in any real problem there may be a number of other "small" features that may lead to very bad outcomes for a seller. For example, if your opponent is cash-constrained and will be a weaker competitor in the future if he pays a higher price now, then this may give you a small incentive to push up the price a little further today, and be strategically equivalent to a small value or ownership advantage. Reputation effects may also be critical. We have already seen that even in the completely symmetric case, asymmetric equilibria can be supported simply by the more aggressive player believing that his opponent will be less aggressive, and vice versa. Bikhchandani (1988) showed that in repeated common-value auctions it may be very easy to develop reputations that support very asymmetric outcomes; bidding a little more aggressively today is rational if it reinforces the bidder's reputation for aggressive behaviour tomorrow.

The immediate moral is that a standard ascending auction may be a very dangerous choice for a seller in an almost common value setting. A wider moral is that auction theory ought to pay more attention to bidder asymmetries. We have spent too long on the symmetric case just because it is easier.[40]

[40]Honourable exceptions, in addition to those papers already mentioned, include Maskin and Riley (1996) and Riley and Li (1997) who have done important work on asymmetric private value auctions. Stevens (1994) analyses asymmetric private value auctions among firms for workers. However small bidder advantages generally have only small effects in private value auctions, at least when there are no entry or bidding costs. When bidders must pay entry costs, Gilbert and Klemperer (1997) show bidder asymmetries can make rationing (i.e. an ex-post inefficient auction) more attractive to a seller than market-clearing (which corresponds to the outcome of an ascending auction).

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