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Bid preference in license auctions: Affirmative action can achieve economic efficiency

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Abstract

If allocative externalities are present among bidders such as when they interact subsequent to the auction, their valuations for the item may differ from their contributions to the social welfare. This paper shows that bid preference in auctions given to those bidders who can contribute more to the social welfare relative to their valuations is an effective measure to achieve efficiency, that is, social welfare maximization. This paper therefore provides a rationale in terms of efficiency for the practice of granting affirmative action bid preferences to minorities or other designated groups. This insight may be applicable to the broader issue of affirmative action programs in general as well.

JEL classification: D44; D62; L13

Keywords: Bid preference; License auction; Affirmative action; Allocative externality

1. Introduction

It is common in many government auctions that a designated group of bidders are treated preferentially. A famous example is the Federal Communications Commission's license auctions for radio spectrum. In these auctions, the FCC has granted businesses owned by minorities and women substantial bidding credits, tax certificates, and other preferential treatments. In particular, favored bidders in the "regional narrowband" license auction for paging services were

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given a 40% bid preference or bidding credit, so that they had to pay only 60% of a winning bid.[1]

This practice of preferential treatment is not special to the sales of government properties. Various governmental agencies such as federal, state, city, and administrative bodies use minority price-preferences in their procurement programs as well. In international trade, many national governments favor domestic firms by explicitly giving bid preferences. Thus, a foreign firm can win a contract only when its bid is lower than the lowest domestic bid by more than a specified bid preference. The United States Government, for instance, has maintained the "Buy-American" program, in which 6% up to 50% bid preferences are granted to domestic suppliers in procurement contracts.[2]

These programs are controversial. The bid preference programs in international trade are recognized as nontariff barriers, and their validity has been challenged. The government auctions and procurement programs, which can be broadly classified as the affirmative action programs, are under serious debate regarding their rationale and effectiveness.[3] One of the grounds against these programs is that they increase the cost of government.

While the origin of these programs is probably political, some recent studies provide an economic justification for them. In particular, McAfee and McMillan (1989) show that the domestic preferences in international procurements can lower the expected price paid by the government for the item. Similarly, Ayres and Cramton (1996) argue that the affirmative action bid preferences in the FCC auctions increased the government's revenue from the sale of the licenses. Corns and Schotter (1999) also prove both theoretically and experimentally that preferential treatment in government procurements can decrease government's cost of purchasing.

What the studies have established is that these programs are not as costly as they appear. On the contrary, bid preferences can increase the government's revenues in the sales of government properties and decrease the government's costs in procurements by creating effective competition among bidders. Due to the preferences given to a subset of bidders, the unfavored bidders have to compete more fiercely among themselves (intragroup competition) as well as with the favored bidders (intergroup competition). This leads to an increase in government's net revenue compared to the situation where no such preferences are given at all. Note that this conclusion is in fact based on Myerson's (1981) theorem on optimal auction design: The seller of an item can increase his revenue by giving bid preferences to weak bidders whose expected willingness to pay for the item is lower. A similar logic applies to the procurement programs in that the buyer of an item can decrease her purchasing cost by giving bid preferences to weak bidders whose expected cost of provision is higher.

These studies, however, miss a more fundamental economic issue in these programs: The issue of whether they improve or impede efficiency.[4] This paper aims to provide an answer to this question. We show, with a stylized license auction model, that bid preferences are effective in achieving efficiency when allocative externalities are present among bidders.

If an allocation of the license to a bidder may affect other bidders such as when bidders in an auction interact subsequent to the auction, it may happen that a bidder's valuation for the license

[1] See Ayres and Cramton (1996) for a detailed discussion.

[2] See McAfee and McMillan (1989) and the references therein.

[3] See Holzer and Neumark (2000) for a comprehensive overview.

[4] Holzer and Neumark (2000) emphasize that efficiency or performance is perhaps the key economic issue in the affirmative action debate, and that economic profession does not provide satisfactory arguments for it.

may differ from the social welfare he can contribute with the license.[5] Hence, traditional auctions which assign the license according to the valuations may produce an inefficient outcome. The main contribution of the present paper is to show that auctions with properly-set bid preferences can eliminate this discrepancy between valuation and social welfare. By granting bid preferences to weak bidders whose valuations are relatively lower than the social welfare they can contribute, the government can ensure that the license be assigned to a bidder with the highest social contribution.

The rest of the paper is organized as follows. We set up a simple Cournot duopoly and present the key observations of the present paper in the next section, and then generalize the model in the following section. Although we present the idea in license auction models in which government properties or public projects are sold, it is clear that the insight can be symmetrically applied to procurement models. The final section contains a fuller discussion of this and related issues.

2. A Cournot duopoly model

Consider two firms in a Cournot oligopoly. Firm i ($i=1,2$) can produce quantity q_i at constant marginal cost c_i. The inverse demand curve is given by $P(Q)=a-Q$, where $Q\equiv q_1+q_2$ is the aggregate supplied quantity. We assume that c_i's as well as the demand curve are known to all parties. We also assume that $c_1<c_2$ so that firm 1 has a cost advantage, and that $c_2<a$. The equilibrium quantities are given by, for $i=1$, 2 and $j=3-i$,

$$q_i = \left(a - 2c_i + c_j\right)/3$$

and the equilibrium profits are given by

$$\pi_i^0 \equiv (q_i)^2 = \left(a - 2c_i + c_j\right)^2/9.$$

The social welfare, which is the sum of firms' profits and the consumer surplus, is

$$sw^0 \equiv (q_1)^2 + (q_2)^2 + (q_1 + q_2)^2/2.$$

The government or a public agency interested in social welfare plans to sell a cost-reducing license to one of the firms. When firm i gets the license, its marginal cost is reduced to d_i, where d_i is drawn from the interval $[\underline{d},\bar{d}]$. We let $\bar{d}<c_1$ such that the license is always cost-reducing even for the firm with a cost advantage. We assume that d_i is a private information such that it is known only to firm i.

2.1. The complete information case

Notwithstanding the previous sentence, we consider in this subsection the case when $d_1=d_2=d$. That is, the new cost level with the license is always the same across the firms. Then, the information structure is *semi*-complete in the sense that the private information d is common

[5] There is a growing literature on allocative externalities. See for example Jehiel et al. (1996) or Jehiel and Moldovanu (2000) and references therein. Although there exist papers that analyze auctions with allocative externalities, most of them study seller's revenue maximization. See, however, Jehiel and Moldovanu (2003) which addresses the general topic of discrepancy between social welfare and value/revenue maximization.

knowledge among firms, though it is not known to the government.[6,7] A mature industry where firms know each other's cost structure with accuracy may be one instance with this information structure. We study this case first since, if not for other reasons, it conveys the main idea of the present paper clearly.

Let π_i^j denote firm i's profit when firm j gets the license. Hence,

$$\pi_1^1(d) = (a - 2d + c_2)^2/9, \quad \pi_2^1(d) = (a - 2c_2 + d)^2/9,$$

$$\pi_1^2(d) = (a - 2c_1 + d)^2/9, \quad \pi_2^2(d) = (a - 2d + c_1)^2/9.$$

We assume that the license is not drastic, so that both firms operate even after the license. Hence, $\pi_i^j(d) > 0$ for all i, j and d. In addition, let $sw^i(d)$ denote the social welfare when firm i gets the license. That is,

$$sw^i(d) = \left(a - 2d + c_j\right)^2/9 + \left(a - 2c_j + d\right)^2/9 + \left(2a - d - c_j\right)^2/18.$$

Since $sw^1(d) - sw^2(d) = (c_2 - c_1)\ (11c_1 + 11c_2 - 8a - 14d) = 18$, the social welfare when firm 1 gets the license is higher if and only if

$$11c_1 + 11c_2 > 8a + 14d. \tag{1}$$

We can define firm i's valuation as

$$v_i(d) \equiv \pi_i^i(d) - \pi_i^j(d).$$

Note that firms' valuations for the license depend on their beliefs about the final outcome. If firm 1 believes that the license will be withheld in case it fails to buy, then its valuation is $\pi_i^i - \pi_1^0$. On the other hand, if firm 1 believes that the license will be awarded to firm 2, then its valuation is $\pi_1^1 - \pi_1^2$. We assume that the license is awarded to one of the firms no matter what.

Since $v_1(d) - v_2(d) = (c_2 - c_1)\ (5c_1 + 5c_2 - 2a - 8d)/9$; firm 1's valuation is higher if and only if

$$5c_1 + 5c_2 > 2a + 8d. \tag{2}$$

Comparing the social welfare and firms' valuations, we have:

Proposition 1. *When it is socially desirable to give the license to firm 1, the valuation of firm 1 is higher.*

Proof. We will show that inequality (1) implies inequality (2). Multiplying 4/7 to inequality (1) gives us

$$44(c_1 + c_2)/7 > 2a + 8d + 18a/7,$$

which in turn gives

$$44(c_1 + c_2)/7 > 2a + 8d + 9(c_1 + c_2)/7.$$

We thus get inequality (2). □

[6] If d is also known to the government, then the problem becomes trivial. As will be clear shortly, the government can just give the license to the firm with a higher social welfare.

[7] We note that what really matters is the common knowledge of firms' new cost levels, not the common value. That is, we can modify the analysis in this subsection, with some notational complication, to allow firms' new cost levels to be different as long as they are common knowledge among firms.

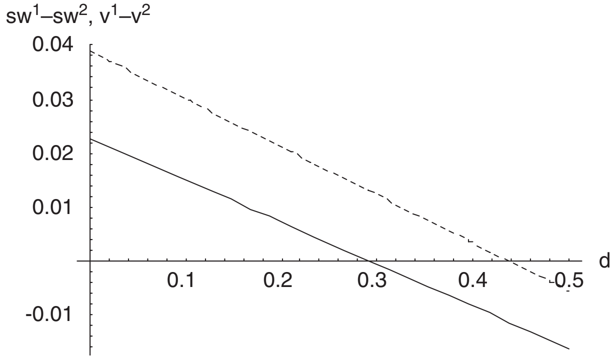

Fig. 1. The behavior of social welfare and valuations.

The proposition also says that it is socially desirable to give the license to firm 2 when firm 2 has a higher valuation. The discrepancy between social welfare and firms' valuations occurs when $sw^1(d)<sw^2(d)$ but $v_1(d)>v_2(d)$. Therefore, if the license is given according to the valuation, we may end up with a socially undesirable outcome. As a specific example, let $a=1$, $c_1=0.5$, $c_2=0.6$. The following graph shows the behavior of social welfare and valuations as functions of d.

In Fig. 1, the solid line shows $sw^1(d)-sw^2(d)$ while the dashed line shows $v_1(d)-v_2(d)$. Hence, for $0.2929<d<0.4375$, it is socially desirable to give the license to firm 2 but firm 1 has a higher valuation. Observe that firm 1 has a higher valuation relative to its contribution to the social welfare since it has a larger market share to defend due to the cost advantage.

Now suppose the government holds a first-price auction to sell the license to one of the firms. Since the cost level d is a common knowledge among firms, they know each other's valuations. Hence, if $v_1(d)>v_2(d)$ then firm 2 will bid $v_2(d)$ and firm 1 will bid $v_2(d)+\epsilon$ in equilibrium, where ϵ is a small positive value.[8] In this case, firm 1 will get the license and pay $v_2(d)+\epsilon$. On the other hand, if $v_1(d)<v_2(d)$ then firm 1 will bid $v_1(d)$ and firm 2 will bid $v_1(d)+\epsilon$ in equilibrium. Thus, firm 2 will get the license and pay $v_1(d)+\epsilon$. (Throughout the paper, we will not discuss the borderline cases, such as when $v_1(d)=v_2(d)$ holds, to keep us out of fruitless complications). Therefore, firm 1 may get the license when it is socially desirable to give it to firm 2.

The government can avoid a misallocation if it gives a properly-set bid preference to firm 2. We now show that a first-price auction with a bid preference given to firm 2 can achieve an efficient outcome, that is, an outcome that maximizes the social welfare.

THE FIRST-PRICE AUCTION WITH BID PREFERENCE: Firms simultaneously submit bids. From firm i's bid b_i, the government calculates the new cost level, denoted as $\tilde{d}_i$, by equating b_i to $v_i(\tilde{d}_i)=\pi_i^i(\tilde{d}_i)-\pi_i^j(\tilde{d}_i)=(2c_i+c_j-3\tilde{d}_i)(2a-2c_i+c_j-\tilde{d}_i)/9$. That is, the government calculates the new cost level assuming that firm i bids its true valuation based on the true cost level d. Of course, $\tilde{d}_i$'s may differ from each other and they may differ from true d. The government also calculates $sw^1(\tilde{d}_1)$ and $sw^2(\tilde{d}_2)$.

[8] To avoid the problems related to the existence of Nash equilibrium, we assume that bidders can add an infinitesimal amount ϵ (but not a smaller amount than that) to their bids. A plausible way to achieve this job, due to Jehiel et al. (1996), is to introduce a smallest money unit ϵ such that all inequalities are preserved if an ϵ is added or subtracted.

(1) A bid preference of

$$z(\tilde{d}_1, \tilde{d}_2) \equiv [b_1 - b_2] - \left[sw^1(\tilde{d}_1) - sw^2(\tilde{d}_2)\right]$$

is added to firm 2's bid. Therefore, the license is awarded to firm 1 if and only if $b_1 > b_2 + z$.

(2) The winning firm pays its bid amount, while the loser pays nothing.

Due to the bid preference, the license is awarded to firm 1 if and only if $sw^1(\tilde{d}_1) > sw^2(\tilde{d}_2)$ in this auction. Therefore, firms in this auction compete to outbid the social welfare, not the valuation. Since firms know true cost level d, the following is a Nash equilibrium. When $sw^1(d) > sw^2(d)$ holds, firm 2 bids $v_2(d)$ and firm 1 bids $v_1(\tilde{d}_1) + \epsilon$, where $\tilde{d}_1$ satisfies the equation $sw^1(\tilde{d}_1) = sw^2(d)$. When $sw^1(d) < sw^2(d)$ holds, firm 1 bids $v_1(d)$ and firm 2 bids $v_2(\tilde{d}_2) + \epsilon$, where $\tilde{d}_2$ satisfies the equation $sw^2(\tilde{d}_2) = sw^1(d)$.

When $sw^1(d) > sw^2(d)$ holds, firm 1 gets the license and its net payoff (compared to the alternative outcome where firm 2 gets the license) is $v_1(d) - v_1(\tilde{d}_1) - \epsilon$. This is strictly positive since both $sw^1(\cdot)$ and $v_1(\cdot)$ are decreasing functions of $\tilde{d}_1$. Therefore, firm 1 does not have an incentive to bid otherwise. Similar arguments for other cases prove that the proposed strategies are indeed an equilibrium.

We illustrate in Fig. 2 how the valuations and bids behave for our numerical example. In the figure, the solid lines represent firms' valuations. When $sw^1(d) > sw^2(d)$, which occurs at $d < 0.2929$, firm 2 bids its true valuation v_2 while firm 1 shades its bid to $b_1 + \epsilon$. (The dashed line shows b_1 for $d < 0.2929$). When $sw^1(d) < sw^2(d)$ with $d > 0.2929$, on the other hand, firm 1 bids truthfully while firm 2 shades its bid to $b_2 + \epsilon$. (The dashed line shows b_2 for $d > 0.2929$). Thus, firm 1's bid as a function of d is $b_1 + \epsilon$ when $d < 0.2929$, and v_1 otherwise. Firm 2's bid is v_2 when $d < 0.2929$, and $b_2 + \epsilon$ otherwise. The bid preference is $b_1 - v_2$ when $d < 0.2929$, and $v_1 - b_2$ otherwise. Note that it is always positive. Given the bidding behavior, the auction achieves efficiency since firm 1 wins if and only if $sw^1(d) > sw^2(d)$. Therefore, the bid preference

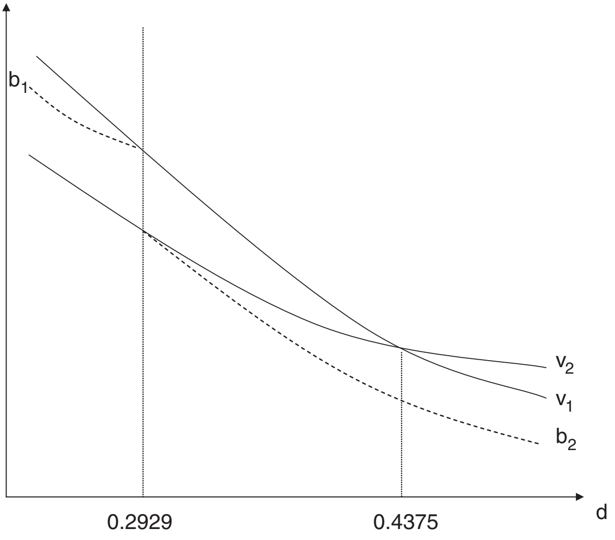

Fig. 2. The behavior of firms' valuations and bids.

$z=[b_1-b_2]-[sw^1(\tilde{d}_1)-sw^2(\tilde{d}_2)]$ added to firm 2's bid is a corrective measure to fill the gap between the social welfare and firms' profits.

2.2. The incomplete information case

Let us resume back to the incomplete information setting, so that each d_i is known only to firm i. Then, for $i=1$, 2 and $j=3-i$, firm i's valuation is

$$v_i(d_1,d_2)=\left(a-2d_i+c_j\right)^2/9-\left(a-2c_i+d_j\right)^2/9$$

and the social welfare when firm i gets the license is

$$sw^i(d_1,d_2)=\left(a-2d_i+c_j\right)^2/9+\left(a-2c_j+d_i\right)^2/9+\left(2a-d_i-c_j\right)^2/18.$$

Note that $sw^{\mathrm{i}}(\cdot)$ depends only on d_i, but not on d_j. This is so since only the winning firm's new cost level is relevant in this setting.

We now present an auction, and show that truth-telling is an ex post equilibrium of this auction. In other words, it is a best reply for each firm to report its private information truthfully, independently of its belief about the other firm's cost distribution. The bid preference to firm 2 in this auction is

$$z(d_1,d_2)=[v_1(d_1,d_2)-v_2(d_1,d_2)]-\left[sw^1(d_1,d_2)-sw^2(d_1,d_2)\right].$$

A BID-PREFERENCE AUCTION: Firms simultaneously report their d_i's. Based on these reports, the government calculates $v_i(d_1,d_2)$'s and $z(d_1,d_2)$. (Note that the reports may be different from the true cost levels with a license. We show in Proposition 2 below that truth-telling is an equilibrium).

(1) The license is awarded to firm 1 if and only if $v_1(d_1,d_2)>v_2(d_1,d_2)+z(d_1,d_2)$. This is equivalent to awarding the license to firm 1 if and only if $sw^1(d_1,d_2)>sw^2(d_1,d_2)$.

(2) The payments are determined as follows.

  (i) When $sw^1(d_1,d_2)>sw^2(d_1,d_2)$: Find d_1^* such that $sw^1(d_1^*,d_2)=sw^2(d_1^*,d_2)$. Since $\partial sw^1(d_1,d_2)/\partial d_1<0$ and $\partial sw^2(d_1,d_2)/\partial d_1=0$, we can find a unique d_1^* with $d_1^*>d_1$. Firm 1 pays $v_1(d_1^*,d_2)$, while firm 2 pays nothing.

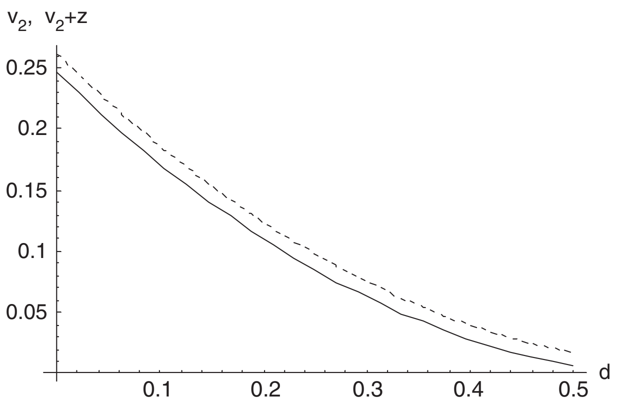

Fig. 3. The magnitude of bid preference.

(ii) When $sw^1(d_1,d_2)<sw^2(d_1,d_2)$: Find d_2^* such that $sw^1(d_1,d_2^*)=sw^2(d_1,d_2^*)$. Since $sw^2(d_1,d_2)/\partial d_2<0$ and $\partial sw^1(d_1,d_2)/\partial d_2=0$, we can find a unique d_2^* with $d_2^*>d_2$. Firm 2 pays $v_2(d_1,d_2^*)$, while firm 1 pays nothing.

We have the following proposition. Since it is a special instance of Proposition 3 of the next section for the general model, we omit the proof here.

Proposition 2. *It is an ex post equilibrium to report truthfully.*

Fig. 3 shows the magnitude of bid preference for the case when d_2 is equal to d_1. The solid line shows v_2 while the dashed line shows v_2+z.

Note that the firm with a smaller market share, i.e., firm 2, is always given a positive bid preference in the auction.

3. The general model

Consider an industry with n firms. Let π_i^0 be firm i's status quo profit. The status quo profits are common knowledge. A government interested in social welfare plans to sell a license (or a project) to one of the firms.[9] Let π_i^j denote firm i's profit after firm j is awarded the license. Profits depend on firms' private information. Thus, if we denote firm i's private information by t_i, then $\pi_i^j=\pi_i^j(t_1,\ldots,t_n)$. We use the notation $\boldsymbol{t}=(t_1,\ldots,t_n)$ to denote the vector of private information. We sometimes use $\boldsymbol{t}=(t_i,t_{-i})$ to highlight i's private information. We assume that each t_i belongs to an interval, and

$$\frac{\partial\left(\pi_i^i(t_i,t_{-i})-\pi_i^j(t_i,t_{-i})\right)}{\partial t_i}>0 \tag{A}$$

for all $i\neq j$. That is, an increase in i's private information increases i's profit when i gets the license more than that when j gets it. Observe that, for the Cournot duopoly model in the previous section, we can set $t_i=\bar{d}-d_i$.

Let $sw^j(\boldsymbol{t})$ denote the social welfare when the license is awarded to firm j and the private information vector is $\boldsymbol{t}=(t_1,\ldots,t_n)$. We assume that

$$\frac{\partial\left(sw^i(t_i,t_{-i})-sw^j(t_i,t_{-i})\right)}{\partial t_i}>0 \tag{B}$$

for all $i\neq j$. That is, an increase in i's private information increases the social welfare when i gets the license more than that when j gets it. Assumptions (A) and (B) are standard single crossing conditions. Observe that the single crossing property is necessary for efficient implementation in ex post equilibrium.[10] In addition, we assume that a firm's private information cannot change the order of other firms' contributions to social welfare. That is, for any three distinct firms i, j, and k, and for any t_i, t'_i and given t_{-i}, we have

$$sw^j(t_i,t_{-i})>sw^k(t_i,t_{-i}) \Leftrightarrow sw^j(t'_i,t_{-i})>sw^k(t'_i,t_{-i}). \tag{C}$$

[9] We can extend the model to the case when the government sells multiple licenses as long as each firm's private information is one-dimensional. Jehiel and Moldovanu (2001) have shown that efficiency is inconsistent with incentive compatibility when valuations are interdependent and private information is multi-dimensional. Note also that this model encompasses industries with incumbents and potential entrants.

[10] See, for example, Dasgupta and Maskin (2000) as well as Ausubel (1999) and Perry and Reny (2002).

In other words, firm i's private information cannot change the order of other firms' $\{sw^j(\cdot,t_{-i})\}_{j\neq i}$. Needless to say, firm i's information may change the order of $sw^i(\cdot,t_{-i})$ with respect to others' social welfare. We note that this assumption is satisfied for the Cournot oligopoly (with more than 2 firms) of the previous section since firm i's new cost level affects only the social welfare when i gets the license. That is, the private information t_i there does not affect $sw^j(\boldsymbol{t})$ for $j\neq i$. We present in Example 1 below why this assumption is needed.

The main functions of an auction (or a mechanism generally) are (1) to elicit private information correctly, and (2) to help form players' expectation about possible outcomes so as (3) to achieve a desirable outcome, which in our case is welfare maximization. We present one such auction below, which is an adaptation of well-known auction formats as in Ausubel (1999) or Perry and Reny (2002) to the environments with allocative externalities. These auction formats are in turn generalizations of the Vickrey–Clarke–Groves mechanism.

A BID-PREFERENCE AUCTION: Firms simultaneously report their t_i's.[11] Based on these reports, the government calculates $\{sw^i(\boldsymbol{t})\}i=1,\ldots,n$.

(1) The license is awarded to a firm with the highest social welfare $sw^i(\boldsymbol{t})$.

(2) Suppose firm i is the winner, and define t_i^* to be the value that satisfies

$$sw^i\left(t_i^*,t_{-i}\right)=\max_{j\neq i}\left\{sw^j\left(t_i^*,t_{-i}\right)\right\}.$$

By (B), the value t_i^* is unique and smaller than t_i, the reported value. Let k be the firm whose social welfare $sw^k(\cdot,t_{-i})$ ties $sw^i(\cdot,t_{-i})$ at t_i^*. (We may in fact define the firm k as arg $\max_{j\neq i}$ $sw^j(\boldsymbol{t})$ since (C) ensures that $sw^j(\boldsymbol{t})$'s for $j\neq i$ is independent of t_i).[12] The winner i pays $\pi_i^i(t_i^*,t_{-i})-\pi_i^k(t_i^*,t_{-i})$, while others pay nothing. This auction ensures truth-telling, and hence welfare maximization.

Proposition 3. *Truth-telling is an ex post equilibrium.*

Proof. Consider a representative firm i with true t_i and reported $\tilde{t}_i$. Let other firms' true and reported private information be t_{-i}.

Case 1. When firm i is the winner with $\tilde{t}_i=t_i$.

Firm i's net payoff when it reports truthfully is $\pi_i^i(t_i,t_{-i})-\pi_i^i(t_i^*,t_{-i})+\pi_i^k(t_i^*,t_{-i})$ where k is defined in the description of the auction above. Now, as long as $\tilde{t}_i$ is such that firm i remains as the winner, there is no change in either allocation or payments at all. In the case when $\tilde{t}_i$ is small enough that i becomes a loser and k becomes the winner, firm i's net payoff becomes $\pi_i^k(t_i,t_{-i})$. Note that we use assumption (C) here since k remains a winner among i's opponents regardless of i's report. The payoff difference is

$$\left[\pi_i^i(t_i,t_{-i})-\pi_i^k(t_i,t_{-i})\right]-\left[\pi_i^i(t_i^*,t_{-i})-\pi_i^k(t_i^*,t_{-i})\right],$$

which is positive by the fact that $t_i^*<t_i$ and (A).

[11] We note again that these reports may be different from true values. Proposition 3 below shows that truth-telling is an equilibrium of the auction.

[12] As stated in the previous section, we do not discuss cases such as when more than one firm tie either as i or as k to keep us out of fruitless complications. As a matter of fact, any pre-determined selection rule will suffice for our purpose if more than one firm tie.

Case 2. When firm i is a loser with $\tilde{t}_i = t_i$.

Firm i's net payoff when it reports truthfully is $\pi_i^k(t_i, t_{-i})$, where firm k is the winner at $\boldsymbol{t} = (t_i, t_{-i})$. Now, as long as $\tilde{t}_i$ is such that firm i is still a loser, there is no change at all. In the case when $\tilde{t}_i$ is large enough that i becomes the winner, firm i's net payoff becomes $\pi_i^i(t_i, t_{-i}) - \pi_i^i(t_i^*, t_{-i}) + \pi_i^k(t_i^*, t_{-i})$. Note again that we use assumption (C) here. The payoff difference is

$$\left[\pi_i^i(t_i^*, t_{-i}) - \pi_i^k(t_i^*, t_{-i})\right] - \left[\pi_i^i(t_i, t_{-i}) - \pi_i^k(t_i, t_{-i})\right],$$

which is positive by the fact that $t_i^* > t_i$ and (A). □

When we considered firm i's possible misrepresentation of t_i in the proof of proposition, we relied on (C) that the winner among i's opponents does not change due to i's report. We now show that truth-telling may not be an equilibrium without (C).

Example 1. Consider 3 firms, and let the vector of true private information be given as $\boldsymbol{t} = (t_1, t_2, t_3)$. Let $sw^1(\boldsymbol{t}) > sw^2(\boldsymbol{t}) > sw^3(\boldsymbol{t})$ as shown in Fig. 4. If firm 1 reports truthfully, then it gets the license and pays $\pi_1^1(t_i^*, t_2, t_3) - \pi_1^2(t_i^*, t_2, t_3)$. Hence, firm 1's net payoff is $\pi_1^1(t_i, t_2, t_3) - \pi_1^1(t_i^*, t_2, t_3) + \pi_1^2(t_i^*, t_2, t_3)$. If firm 1 reports $\tilde{t}_1$ instead, then firm 3 gets the license and firm 1's net payoff is $\pi_1^3(t_i, t_2, t_3)$. As long as

$$\pi_1^3(t_1, t_2, t_3) - \pi_1^2(t_1^*, t_2, t_3) > \pi_1^1(t_1, t_2, t_3) - \pi_1^1(t_1^*, t_2, t_3),$$

firm 1 has an incentive to lie. And this may happen when firm 3 is a weak competitor to firm 1 so that firm 1's profit does not decrease as much when firm 3 gets the license as when firm 2 gets it. Observe that $sw^2(\cdot)$ and $sw^3(\cdot)$ in this example do not satisfy assumption (C).

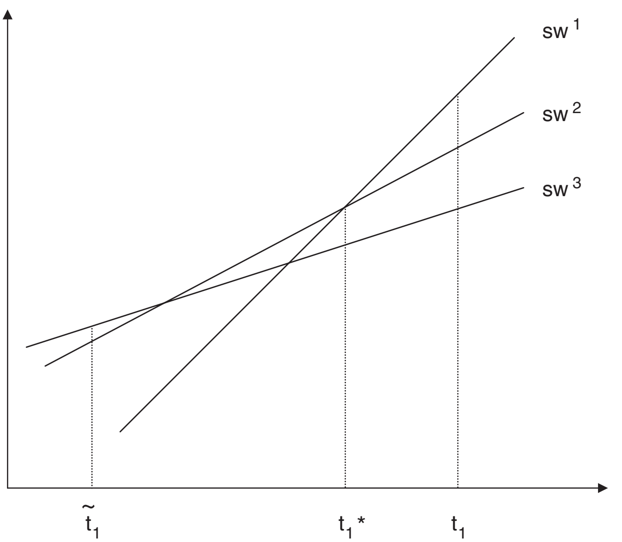

Fig. 4. A counter-example violating (C).

We can define firm i's valuation $v_i(\boldsymbol{t})$ to be $\pi_i^i(\boldsymbol{t})-\pi_i^k(\boldsymbol{t})$, where the firm k is defined above. Then, the bid preference given to firm i in the auction can be thought as

$$z_i(\boldsymbol{t}) = sw^i(\boldsymbol{t}) - v_i(\boldsymbol{t}).$$

Therefore, a bigger bid preference is given to firm i if the social welfare it achieves is relatively higher than its valuation.

4. Discussion

We have shown that bid preference in auctions is an effective measure to achieve efficiency when bidders' valuations are different from their respective contributions to the social welfare. We observed that this discrepancy may occur if allocative externalities are present among bidders, such as when they interact subsequent to the auction.

We have found that bigger bid preferences should be granted to those bidders who can contribute more to the social welfare relative to their valuations. We have demonstrated this result in Section 2 with a stylized Cournot duopoly in which firms have different marginal costs of production. As the analysis in Section 3 implies, however, this insight can be equally applied to more general situations. For instance, if firms have differing capital costs or budget constraints, then bid preferences given to financially weak bidders can fill the difference between the social welfare and valuation to achieve efficiency. The same insight may also shed some light on the broader issue of affirmative action programs in general. In particular, the fact that a group of people or firms have disadvantageous opportunities alone is not sufficient for affirmative actions. Another condition is allocative externalities, so that this group interacts with others and contributes more to the social welfare. I believe this condition holds in many situations.

Bidders in our bid-preference auction for the incomplete information case report their private information rather than monetary bids. That is, we have constructed a direct revelation mechanism. While this faithfully follows the common practice in the literature,[13] we still admit that the auction may not be applicable to real-world situations. Note however that the first-price auction with bid preference for the complete information case is real enough to be applicable. Moreover, to correctly set the magnitude of bid preferences, the government or the auctioneer needs to know the structure, i.e., the functional form, of bidders' valuations and the social welfare they contribute. This might be a hard task, which is probably why we often observe bid preferences that are fixed to a pre-specified level across many runs of the same auction.[14] On the other hand, the main purpose of the present paper is to provide a new perspective on affirmative action bid preference, not its practical implementation.

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[13] As stated in the previous section, the bid preference auction for the incomplete information case is an adaptation of well-known auction formats as in Ausubel (1999) or Perry and Reny (2002) to the environments with allocative externalities.

[14] It seems to be an interesting research agenda to compute the bound of welfare loss for the simple bid-preference rules. I thank an associate editor for this comment.

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