When do simple policies win?

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Abstract: We present a simple model of a debate between two interested parties which takes into account the complexity of their policy positions. The two debaters engage in all-pay-auctions to win slots of time/attention to present their positions to a decision maker. Complexity of a policy is modelled through the number of slots of attention needed to get the policy across. We show that when the number of attention slots is scarce, but still large enough to allow for both sides to fully present all their policies, simple policies have an advantage over more complex ones. We show that this advantage of simple policies is diminished only when the number of attention slots is fairly large and when the decision maker is strongly persuaded by more complex policies.

1 Introduction

It is often claimed that simple policies are advantageous in public debates, and that the short sound-bites of media appearances make it difficult to create public understanding of complex issues. This is usually the criticism targeted towards televised Presidential debates, as "it is difficult to explain complex issues on TV, so less information is presented".[1] In this paper we analyze a model of debates with simple and complex policies.

We assume that two players, each representing a different policy alternative, engage in a debate in which they present statements explaining their policy to a decision maker. To do so, the debaters engage in an all-pay-auction to win slots of time/attention of the decision maker. The winner of each such slot can present a statement. We distinguish between policies based on the number of slots needed to convey them; simpler policies can be explained with fewer statements.

We highlight a strategic force that benefits simple policies in debates. Rent extraction in an all-pay-auction creates a disadvantage for policies that demand more slots of attention to be explained. A sequential debate allows players who represent

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[1] Hellweg, Susan A., *Televised Presidential Debates.* New York: Praeger, 1992, Chapter 4.

such complicated policies to commit to avoid competition or to "back off". Surprisingly, this advantage of simple policies holds also when attention is not too limited, so that the decision maker has more than enough slots of attention to hear both policies fully. The advantage of simple policies is diminished (and reversed) when the decision maker has a relatively large amount of time or attention and when conditional upon observing both the simple and the complicated policy, he strongly prefers the complicated one. In that case players still avoid bidding wars on equilibrium path by allowing each to fully present their statements and not competing for the same slots.

We also show that the strategic advantage of simple policies is weakened in a simultaneous debate, where feedback is not provided to the players throughout the process about which statements had won the attention of the decision maker in the past. Finally, we allow each debater to choose the level of complexity of his policy prior to the debate and show that given the exogenously given number of attention slots, when the decision maker values complicated policies, the chosen policies will be of moderate complexity.

Glazer and Rubinstein (2001) model a debate in which, due to time constraints, debaters cannot present all of their information to a decision maker. Using a mechanism design approach, they show that sequential debates are better for the decision maker, as they allow the debater with "truth" on her side to better reveal her opponent's lack of evidence. In contrast to Glazer and Rubinstein (2001) the advantage of a player in our model stems from the simplicity of his policy, which provides higher incentives to outbid her opponent, rather than from any normative advantage.

Konrad and Kovenock (2006) model patent races using sequences of all-pay-auctions with instantaneous prizes. Our model differs as we have no instantaneous prizes and the number of slots each player has to win is asymmetric. We also focus on other questions such as the comparison to simultaneous debates and the possibility that debaters choose their own complexity level. Also related is Klumpp and Polborn (2007), who analyse sequential and simultaneous primaries. They show that simultaneous primaries imply higher expenditures.

More generally, our paper relates to political influence and campaign expenditures. Several papers assume that money directly affects voters' preferences (see for example Grossman and Helpman 2001, and more recently Morton and Myerson, forthcoming, and Iaryczower and Mattozzi, forthcoming). In contrast, we assume that such expenditures affect preferences indirectly by allowing voters or decision makers to become aware of available policies.

The remainder of the paper includes the presentation of the model (below) and the main result, in Section 3. Two extensions are provided in Section 4 and Section 5 concludes with a brief discussion of the assumptions of the model. An appendix contains the proof of the main result, Proposition 1.

2 The model

A decision maker is facing a decision problem but he is unaware of the feasible alternatives he can choose from. We assume that beyond taking no action (ϕ), there are two feasible alternatives to choose from, A and B. Two players/debaters $i \in \{1, 2\}$ are representing these alternatives, with player 1 (2) representing option A (B). The debaters know the feasible alternatives.

We assume that the decision maker faces time and attention constraints. In particular, she has a finite number, T, of (subsequent) time/attention slots. In each such slot she can register only one "statement". A "simple" policy needs to register less statements in order to be explained or understood than a "complicated" one. We consider an asymmetric situation, in which A is a simpler policy that needs α attention slots to be understood, whereas B needs $\beta > \alpha$ slots. For a non-trivial model, let $T \geq \beta$. There are two potential environments. In a limited attention case, the decision maker cannot understand both policies, i.e., $T < \alpha + \beta$. In the abundant attention case, we have $T \geq \alpha + \beta$, so that potentially the decision maker can understand both policies.

We assume that players compete to capture the attention of the decision maker by "winning" attention slots. We model this competition by an all-pay-auction in which the winner captures all the attention of the decision maker for that time/attention slot. Formally, each debater i submits in each period $t \in \{1, 2, ..., T\}$ a bid $b_i^t \in [c, \infty) \cup \{0\}$ with $c > 0$ being entry cost and a zero bid implying no participation in the auction. These bids can be taken literally as access fees or advertisement cost, or more generally as effort or resources expanded to win attention. The assumption that players have to pay an entry cost is mainly to ensure equilibrium existence; we can therefore think of these as very small. In reality this could approximate the need to make an initial investment to catch someone's attention, or discreteness in advertisement space in newspapers.

For each time/attention slot t the decision maker registers the "statement" presented by the highest bidder when both have paid at least the minimum bid c (and each with some positive probability if both placed the same bids). If neither player paid the entry cost, no information is registered. In our main result, we consider a *sequential* debate, i.e., when bidders enter period $t+1$ observing the slot winner at period t. A sequential debate can represent campaigns in which polls are conducted after every period so that politicians are aware of what message "got across".[2]

After the last period, if only one policy was presented in full, the decision maker will choose it (i.e., he prefers both A and B to no decision), whereas we assume that if both policies were understood by the decision maker she chooses option B with probability $p(\alpha,\beta) \in [0.5,1]$. The assumption that option B is preferred is the more interesting assumption, as it potentially creates a trade-off between simplicity and attractiveness. This also captures the idea that an option which is more thoroughly explained can be more convincing. The results could easily be generalized to relax this assumption.

Player $i's$ utility from his alternative being picked is $v_i - \sum_{t=1,2,\ldots,T} b_i^t$ and is $-\sum_{t=1,2,\ldots,T} b_i^t$ when his alternative is not picked, where we assume that $v_i > Tc$. To illustrate our results, we consider the simplest case where $v_i = v_j = v$.[3] If no decision is taken, let pay-offs be $(\varepsilon, \varepsilon)$ where $\varepsilon \leqslant 0$ for all i.[4] We will focus on subgame perfect equilibria. The following Lemma about all-pay auctions will prove useful in what follows:

Lemma 1 *Suppose that two players play an all pay auction with reservation price* c*, such that: if Player 1 wins the pay-offs are* (v_1^1, v_2^1) *if Player 2 wins they receive* (v_1^2, v_2^2) *and if no one wins they receive* (v_1^ϕ, v_2^ϕ)*. Assume that either* $v_1^1 \geqslant v_1^\phi$ *or* $v_2^2 \geqslant v_2^\phi$*. Finally, assume that* $v_1^1 \geqslant v_1^2$ *and* $v_2^2 \geqslant v_2^1$ *and without loss of generality assume that* $v_1^1 - v_1^2 \geqslant v_2^2 - v_2^1$*. When* $c \to 0$ *the pay-offs in any equilibrium of this game converge to* $(v_1^2 + ((v_1^1 - v_1^2) - (v_2^2 - v_2^1)), v_2^1)$*.*

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[2] In Section 4 we consider a simultaneous debate, in which the debaters are not aware of the statement registered by the decision maker before they bid for the next slot. This may represent environments in which candidates bid ex ante for multiple advertisement slots.

[3] The valuation can represent either a winning motive or a policy motivation, where v_i is the difference in utilities of player i from having his own policy implemented vs. his rival's one.

[4] This assumption is mainly for simplicity. The results are robust to a sufficiently small $\varepsilon > 0$. If $\varepsilon > 0$ is large, the results could be generalized although the outcome of no decision will happen with strictly positive probability on equilibrium path.

This is a standard result in a two-player all-pay-auction game, adopted for the entry cost case. Specifically, for each c, arguments as in Hillman and Riley (1989) imply that the bidding will be a continuous distribution with no atoms on $(c, v_2^2 - v_2^1]$. The unique equilibrium will then consist of a uniform distribution on $(c, v_2^2 - v_2^1]$ with an atom on 0 for Player 2 and an atom on c for Player 1. The density for Player 1 is $\frac{1}{v_2^2-v_2^1}$ and for Player 2 it is $\frac{1}{v_1^1-v_1^2}$ so that atoms are of measure $\frac{c}{v_2^2-v_2^1}$ and $1-\frac{v_2^2-v_2^1-c}{v_1^1-v_1^2}$ for Players 1 and 2 respectively. As $c \to 0$ the atoms converge to 0 and $1-\frac{v_2^2-v_2^1}{v_1^1-v_1^2}$ for Players 1 and 2 respectively. This implies pay-offs of $(v_1^2 + ((v_1^1 - v_1^2) - (v_2^2 - v_2^1)), v_2^1)$.[5]

3 The advantage of the simple policy

Below we show that the simple policy wins the debate with probability one as long as the debate is not too long. Surprisingly, this happens even in cases in which the debate is long enough to potentially allow the decision maker to register both policies, i.e., when $T \geqslant \alpha + \beta$.

For what we do below it would be helpful to bunch together histories of the game that imply the same continuation utilities and qualitatively similar behaviours. First, we say that a history is in an "A state" if Player 2 does not participate in any subsequent auction, and Player 1 presents all his α statements, by paying the minimum reservation price. There are of course many such observationally equivalent paths of play as Player 1 can use the last α slots or the first ones or anything in between. In such a state Player 1 wins with probability one. Similarly we can define a "B state". In an "*AB state*", both players present all their arguments so that both policies are registered, again, at a minimum cost, that is, they do not engage in any bilateral competition but at each period either Player 1 or Player 2 presents an argument by paying the minimum cost while the other player abstains. Again, there are many observationally equivalent such paths and in each Player 1 wins with probability $1 - p(\alpha, \beta)$ and Player 2 wins with probability $p(\alpha, \beta)$.

We can now present our main result (for expositional purposes, the case in which both $\beta = \alpha + 1$ and $T = \alpha + \beta$ is discussed later):

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[5] The formal proof follows Hillman and Riley (1989) and is thus omitted.

Proposition 1 *In any subgame perfect equilibrium: (i) if $T < 2\beta - 1$ Player 1 wins with probability one and the game begins in an A state; (ii) if $T > 2\beta - 1$ Player 1 wins with probability $1 - p(\alpha, \beta)$ and the game begins in an AB state; (iii) if $T = 2\beta - 1$, Player 1 wins with probability $\frac{1}{2} + \frac{1}{2}(1 - p(\alpha, \beta))$. The game begins with both players bidding in the first round and each winning with probability $\frac{1}{2}$; if Player 1 wins this round the game is in an A state and if Player 2 wins, the game is in an AB state.*

The first implication of the above proposition is that in the sequential game players are able to almost fully commit not to engage in needless bidding wars. If Player 1 is advantageous enough, Player 2 gives up from the start. If Player 1 is deemed not advantageous, they both present their arguments almost costlessly. The second implication, is that despite Player 2's advantage through $p(\alpha, \beta)$, there is no B state in equilibrium. For all T, the policy of Player 1 is always presented with strictly positive probability irrespective of how close $p(\alpha, \beta)$ is to one; moreover, for T in $\{\alpha + \beta, ..., 2\beta - 1\}$, Player 1 wins with probability one. We now explain the intuition for these latter observations.

First, let us consider the case of $T < \alpha + \beta$. Assume for example that $\alpha = 1, \beta = 2$ and $T = 2$. The following game tree describes the moves of the game as well as the continuation pay-offs (taking c to zero). Also, for the sake of exposition, we denote only the nodes at which some player has won in each history.

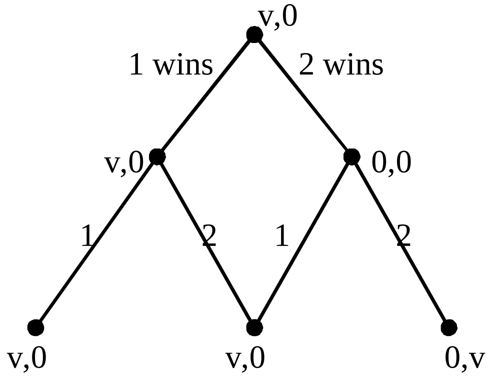

Figure 1: $\alpha = 1, \beta = 2, T = 2$.

For example, following a first period win of Player 1, if Player 1 wins again then the continuation pay-offs (not accounting for any past or present payments) would be $(v, 0)$. The same continuation pay-offs will hold if Player 2 or no player will win. Thus, folding the game backward, if Player 1 wins the first slot, he expects a continuation payment of $(v, 0)$ as neither player will participate in the second auction and he would win for sure.

Consider now a first period win of Player 2. If he goes on to win again, the pay-offs would be $(0, v)$ whereas if Player 1 wins, it would be $(v, 0)$ and no registered statement would yield $(\varepsilon, \varepsilon)$. This implies that the willingness to win of both players is v, and that a bidding war which completely extracts all the rents would ensue, by Lemma 1, leaving players with a continuation utility of $(0, 0)$. Therefore, Player 2 is better off not engaging in any bidding in the first stage and the game will start in an A state.

More generally, consider again games in which each of the slots is captured by some agent. The terminal continuation pay-offs in the game where $T < \alpha + \beta$ can only be $(v, 0)$ or $(0, v)$. Pay-offs are $(v, 0)$ for β terminal nodes (when Player 2 wins $\beta - 1$ slots or less). In the remaining $T + 1 - \beta$ terminal nodes, pay-offs are $(0, v)$. But notice that there is a sufficient (relative) number of terminal nodes in which Player 1 wins, or in other words, $T + 1 - \beta < \beta$ (as $T < \alpha + \beta \leq 2\beta - 1$). This implies that as above, when we fold back the game tree, Player 1 knows that an initial win will lead to a path reaching one of these events for sure. On the other hand a win for Player 2 guarantees that at some point the players will face a full-on bidding competition resulting in a $(0, 0)$ payoff which is not worth the initial win of Player 2.

Now assume that $T > \alpha + \beta$. In all terminal nodes in which Player 2 had won $0, 1, ..., \beta - 1$ slots, the continuation pay-offs will be $(v, 0)$ whereas in all terminal nodes in which player 1 had won $0, 1, ..., \alpha - 1$ slots then the payoff will be $(0, v)$. Finally in all other nodes, in which Player 1 won at least α slots and Player 2 won at least β slots, the continuation payoff is $((1 - p)v, pv)$. But similarly to our above analysis, if $T < 2\beta - 1$, more than half of the terminal nodes lead to a payoff of $(v, 0)$. This implies that at the start of the game, as before, a win by Player 1 would lead to a payoff of $(v, 0)$. On the other hand, as $T > 2\alpha - 1$, a win by Player 2 will not lead to a payoff of $(0, v)$ and moreover will yield him a payoff of zero. As a result, Player 2 will forfeit the game to Player 1.

When $T > 2\beta - 1$ the game is long enough so that Player 1 cannot guarantee a win by winning first. But there is a large number of final events in which both policies are presented and thus the final continuation pay-offs will be $((1 - p)v, pv)$. These payoffs can persist along the game tree. For example, suppose that at stage T

players expect $((1-p)v, pv)$ if 1 wins and $(0, v)$ if 2 wins (as can be seen at the most right-hand final subgame of Figure 2). Then at stage $T-1$ the continuation value, according to Lemma 1, is $(0, pv)$. But then at stage $T-2$, a win for Player 2 will yield the continuation value of $(0, pv)$ while a win for Player 1 will yield $((1-p)v, pv)$. Player 2 has therefore no motivation to participate in the auction and will thus let Player 1 win. Thus the continuation payoff vector $((1-p)v, pv)$ is persistent and can "climb" up the tree to yield an AB state. Such a continuation payoff at the beginning of the tree implies that throughout the tree, conflicts may arise off equilibrium path, but players choose the path to avoid them and instead allow each other to present their policies in full:

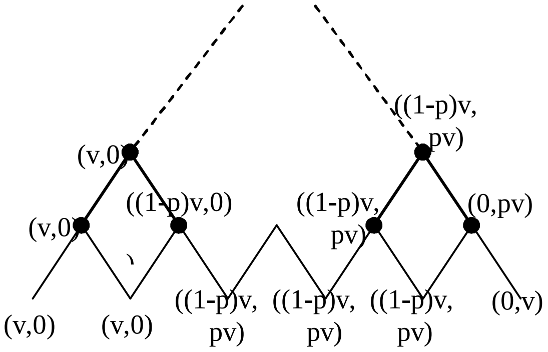

Figure 2: A game tree with $T = 6, \alpha = 1$ and $\beta = 2$.

Finally, the omitted case of $\alpha = \beta - 1$ and $T = \alpha + \beta = 2\beta - 1$ results in Player 1 winning with probability larger than a half, and Player 2 receiving a payoff of zero in equilibrium as in the general case of $T = 2\beta - 1$. However, as α and β are close and competition is fierce, the observed equilibrium path involves more contested slots. The positive description of the actual bidding is thus more complicated but note that monotonicity is still preserved as in the general case, as for all $T < \alpha + \beta$ Player 1 wins for sure, for $T = \alpha + \beta$ Player 1 wins with a probability larger than a half, and for $T > 2\beta - 1$ Player 1 wins with probability $1 - p(\alpha, \beta) < \frac{1}{2}$.

4 Extensions

We now discuss two extensions of the model. In the first we consider a simultaneous debate. The sequential model has implied a strategic advantage for Player 1 in debates with relatively low attention slots and an advantage for Player 2 when attention slots were relatively numerous. Our result shows that simultaneous debates tend to lower both kinds of strategic advantages. We then analyze, in the context of sequential debates, the incentives to choose the complexity of policies. We show that the competition between the debators induces a relatively high level of complexity but still low enough to allow both players to fully present their policies.

4.1 Simultaneous debates

Assume now that each player i submits a vector of bids $\mathbf{b}_i = \{b_i^1, b_i^2, ..., b_i^T\}$ at the beginning of the game. Our first result shows that the stark advantage of Player 1 who wins for sure for all $T < 2\beta - 1$ in the sequential game does not arise in the simultaneous game:

Proposition 2 *For any T there exists an $\varepsilon > 0$ such that the probability that Player 2 wins the simultaneous debate is larger than ε.*

Proof of Proposition 2: Consider the simultaneous debate. Let γ be the probability that Player 2 wins in equilibrium. Suppose for any $\bar{\varepsilon}$, there exists an $\varepsilon < \bar{\varepsilon}$, such that there exists an equilibrium in which the probability that Player 2 wins $\gamma < \varepsilon$. Consider a sequence of equilibria with a such corresponding sequence $\{\gamma_n\}_{n=1}^{\infty}$ satisfying $\gamma_n \to 0$. Note that in equilibrium the expected value of all bids submitted by Player 2 must satisfy: $Ex(\tilde{\mathbf{b}}_2) \leq \gamma_n v$. As $\gamma_n \to 0$, for any $\bar{b}_n > 0$, there is a large enough n such that $Ex(\tilde{\mathbf{b}}_2) < \bar{b}_n$ and $T\bar{b}_n < v$. Consider a sequence of strategies in which Player 1 places $\bar{b}_n$ on all slots. For large enough n Player 1 can guarantee his willingness to win v at shrinking costs. Therefore, the strategy $\bar{b}_n$ will form an upper bound on the bids of Player 1. But this implies that Player 2 can deviate, by biding a sequence $b_{2,n} > \bar{b}_n$ in all slots, to recover his willingness to win, a contradiction.■

To illustrate the difference between the sequential and the simultaneous debate, consider now the following example with $T = 2$, $\alpha = 1$ and $\beta = 2$. In the sequential game, this results in a sure win for Player 1 as depicted in Figure 1.

Lemma 2 *The following is an equilibrium: Player 1 draws one bid from a uniform distribution over $[c, v/2]$ and places this strictly positive bid in time/attention slot 1 (2) with probability $\frac{1}{2}(\frac{1}{2})$. Player 2 draws a bid from a uniform distribution over $[c, v/2]$, and places this bid in each slot. The probability that each player wins is strictly positive with Player 1 winning with a probability converging to $\frac{3}{4}$ when $c \to 0$.*

Proof of Lemma 2: To characterize the equilibrium behaviour, consider first the utility of Player 1. Suppose that Player 1 places two different bids $b_1^i \geq b_1^j > 0$ for slots $i \neq j$. Since Player 2 places the same bid in both slots, Player 1 would increase his payoff by setting $b_1^j = 0$. Thus Player 1 places a positive bid only in one slot.

Note that we consider $b_2^1 = b_2^2 = b_2$ for Player 2 in slots $1, 2$. Let $F_2(b)$ be the probability that $b_2 < b$. Player 1's utility from submitting a bid b in any slot is then

$$F_2(b)v - b.$$

Player 1's utility from placing a positive bid must be equal for any b in the support implying the first order condition:

$$\begin{aligned} \frac{\partial F_2(b)}{\partial b} v &= 1 \Rightarrow \\ F_2(b) &= \frac{b}{v} + \frac{1}{2} \end{aligned}$$

for all $b \in [c, \frac{v}{2}]$.

Given the equilibrium behaviour of Player 1, denoted by $F_1(b)$ and the equal mixing between slots, Player 2's utility from (positive) b_2^1 and b_2^2 is:

$$\frac{1}{2} F_1(b_2^1)v + \frac{1}{2} F_1(b_2^2)v - (b_2^1 + b_2^2)$$

The first order conditions are

$$f_1(b_2^1))v = 2; \;\; f_1(b_2^2))v = 2$$

This must hold for any b_2^1 and b_2^2 in the support and is satisfied by the conjectured behaviour of Player 1.

Finally the probability of Player 2 winning when $c \rightarrow 0$ is:

$$\int_0^{\frac{v}{2}} [\frac{1}{2}(1 - F_2(b)) + \frac{1}{2}(1 - F_2(b))] \frac{2}{v} db = \frac{1}{4}. \blacksquare$$

Note that Proposition 2 also implies that the advantage of Player 2 -when T and p are large– is not as stark in the simultaneous game. In particular, when $T > 2\beta - 1$ and $p(\alpha, \beta) \rightarrow 1$, Player 1 wins the sequential game with probability converging to zero but with a strictly positive and bounded probability in the simultaneous game.[6]

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[6] Note that the proof of Proposition 2 can be repeated in this case with change of players' labels.

4.2 Strategic choice of complexity

In this section we allow debaters to choose the complexity of their policies, to potentially trade-off simplicity of policies with the value that the decision maker attaches to a complicated one. We uncover a simple intuition that players race to choose a more complicated policy than their rival, but not too complicated.

Assume that prior to the (sequential) debate each player chooses the number of statements he needs in order to put his policy through, denoted by $\alpha_i \in \{1, .., T\}$. In the spirit of the main model, we assume that a policy represented by more statements is more likely to win. Thus the probability of player i winning if $\alpha_i \geq \alpha_j$ is $p_i(\alpha_i - \alpha_j) \in [0.5, 1]$ where $p(.)$ is strictly increasing and $p(0) = 0.5$. We analyze the following game: At stage 1 each debater chooses α_i and given these public choices, the players play the sequential debate with $T \geq 3$ stages.

To consider an example, suppose that $T = 7$ and $\alpha_1 = 1$. The best response of Player 2 will be to choose the most complex policy that will enable full presentation of both policies in equilibrium namely the maximum value of α_2 that satisfies $\alpha_2 < \frac{T+1}{2}$, i.e., $\alpha_2 = 3$. But given $\alpha_2 = 3$, Player 1 can do better by choosing instead $\alpha_1 = 3$. Thus, the main strategic force in this interaction leads players to choose policies which are more complicated than that of their rival in order to take advantage of the p function, but not too complicated so that they will not be presented at all. Final chosen policies will be of mid-complexity level and will allow both policies to be presented. We therefore have:

PROPOSITION 3 *Assume that $T \geq 2$. In the unique equilibrium both debators choose $\alpha_1 = \alpha_2 = \lceil \frac{T-1}{2} \rceil$ and both policies are presented in equilibrium. Equilibrium pay-offs are $(\frac{1}{2}v, \frac{1}{2}v)$.*

Proof: Given that player i chooses $\lceil \frac{T-1}{2} \rceil$, player j's best response is to choose the same; if he chooses less he will have a payoff of $(1 - p(\alpha_i - \alpha_j))v < \frac{1}{2}v$ and if he chooses more he will have a payoff of zero. The best response correspondence is to choose $\lceil \frac{T-1}{2} \rceil$ if the other player chooses below $\lceil \frac{T-1}{2} \rceil$ and to choose a number strictly below $\lceil \frac{T-1}{2} \rceil$ if the other player chooses above $\lceil \frac{T-1}{2} \rceil$. Therefore, the unique equilibrium is $(\lceil \frac{T-1}{2} \rceil, \lceil \frac{T-1}{2} \rceil)$.■

5 Discussion

We have presented a simple model of the complexity of arguments in debates. Our analysis formalises the notion that simple arguments are better suited to debates that involve an audience with a short or limited attention span. We show that this advantage exists even when the debates are long enough to potentially accommodate all sides being heard by the audience. On the other hand, when attention is relatively large, more complex arguments enjoy an advantage when they are more influential than simple ones. When we analyse the incentives for choosing the complexity of arguments we find that debaters will choose moderate levels of complexity which imply that both sides are heard by the audience.

Note that we have made some simplifying assumptions in our analysis. First, we assumed that players weakly prefer the policy of their rival to no decision. Relaxing this assumption will imply that sometimes no decision will be taken, but the strategic advantage of simple arguments will similarly arise in such a model. We have also assumed a particular influence function, the all pay auction. Alternatively, one can use other more smooth influence functions (such as the Tullock family of influence functions) but these, again, will yield similar results (although naturally less stark). Both players were assumed to have the same intensity of winning. Again relaxing this assumption maintains the robustness of the result, as long as the winning motivation of Player 2 is not too large compared with that of Player 1. Finally, we have assumed that the preferences of the decision maker over policies A and B depend only on their complexity; it is naturally possible to build in some inherent preference for one of these policies and maintain the qualitative nature of the results.

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6 Appendix

Proof of Proposition 1:

At any time t, let $\alpha(t)$ be the number of slots already won by player 1 up to and excluding period t and similarly define $\beta(t)$. Note that as sometimes players will prefer not to participate in the auction, it may be that $\alpha(t) + \beta(t) < t - 1$. The important variables in the proof below will be $\alpha^*(t) = \alpha - \alpha(t)$ and $\beta^*(t) = \beta - \beta(t)$, i.e., the remaining number of slots each option has to win in order to be registered (whenever no confusion occurs, we will drop the index t). Similarly, $T^* = T - t + 1$ will denote the number of remaining slots at the beginning of period/slot t. For brevity, let $p = p(\alpha, \beta)$.

We will characterize the continuation pay-offs in equilibria as well as all subgame perfect strategies by induction. For the first steps of the induction we analyze using Lemma 1 all possible pay-offs for $T^* \in \{1, 2, 3, 4, 5\}$ and then present the induction hypothesis.

Step 1: $T^* = 1$.

By Lemma 1 above, it easy to compute the following continuation pay-offs at $T^* = 1$ for all possible values of α^*, β^*:

$T^* = 1, \alpha^*, \beta^*$	$Payoffs$	
$\alpha^* = \beta^* = 0$	$((1-p)v, pv)$	
$\alpha^* = \beta^* = 1$	$(0, 0)$	
$\alpha^* = 1, \beta^* > 1$	$(v, 0)$	
$\alpha^* = 0, \beta^* = 1$	If 1 wins $(v, 0)$ if 2 wins $((1-p)v, pv)$ if no one wins $(v, 0)$	$\Rightarrow ((1-p)v, 0)$
$\alpha^* > 1, \beta^* > 1$	$(\varepsilon, \varepsilon)$	
$\alpha^* = 1, \beta^* = 0$	If 1 wins $((1-p)v, pv)$ if 2 wins $(0, v)$ if no one wins $(0, v)$	$\Rightarrow (0, pv)$
$\alpha^* > 1, \beta^* = 1$	If 1 wins $(\varepsilon, \varepsilon)$ if 2 wins $(0, v)$ if no one wins $(\varepsilon, \varepsilon)$	$\Rightarrow (0, v)$

Step 2: $T^* = 2$: By Lemma 1 and Step 1 we have:

$T^* = 2, \alpha^*, \beta^*$	$Payoffs$	
$\alpha^* = \beta^* = 0$	$((1-p)v, pv)$	
$\alpha^* = \beta^* = 1$	If 1 wins $((1-p)v, 0)$ if 2 wins $(0, pv)$ if no one wins $(0, 0)$	$\Rightarrow (0, (2p-1)v)$
$\alpha^* = \beta^* \geq 2$	If 1 wins $v, 0)$ if 2 wins $(0, v)$ if no one wins $(\varepsilon,\varepsilon)$	$\Rightarrow (0, 0)$
$\alpha^* = 0, \beta^* = 1$	If 1 wins $((1-p)v, 0)$ if 2 wins $((1-p)v, pv))$ if no one wins $((1-p)v, 0)$	$\Rightarrow ((1-p)v, pv)$
$\alpha^* = 0, \beta^* \geq 2$	If 1 wins $(v, 0)$ if 2 wins $((1-p)v, 0)$ if no one wins $(v, 0)$	$\Rightarrow (v, 0)$
$\alpha^* = 1, \beta^* \geq 2$	If 1 wins $(v, 0)$ if 2 wins $(0, 0)$ if no one wins $(v, 0)$	$\Rightarrow (v, 0)$
$\alpha^* = 2, \beta^* > 2$	If 1 wins $(v, 0)$ if 2 wins $(\varepsilon,\varepsilon)$ if no one wins $(\varepsilon,\varepsilon)$	$\Rightarrow (v, 0)$
$\beta^* = 0, \alpha^* = 1$	If 1 wins $((1-p)v, pv)$ if 2 wins $(0, pv)$ if no one wins $(0, pv)$	$\Rightarrow ((1-p)v, pv)$
$\beta^* = 0, \alpha^* \geq 2$	If 1 wins $(0, pv)$ if 2 wins $(0, v)$ if no one wins $(0, v)$	$\Rightarrow (0, v)$
$\beta^* = 1, \alpha^* \geq 2$	If 1 wins $(0, 0)$ if 2 wins $(0, v)$ if no one wins $(0, v)$	$\Rightarrow (0, v)$
$\beta^* = 2, \alpha^* \geq 3$	$(0, v)$	

Step 3: $T^* = 3$. By Lemma 1 and Step 2 above, we have:

$T^* = 3, \alpha^*, \beta^*$	$Payoffs$	
$\alpha^* = \beta^* = 0$	$((1-p)v, pv)$	
$\alpha^* = \beta^* = 1$	If 1 wins $((1-p)v, pv)$ if 2 wins $((1-p)v, pv)$ if no one wins $(0, (2p-1)v)$	$\Rightarrow ((1-p)v, pv)$
$\alpha^* = \beta^* = 2$	If 1 wins $(v, 0)$ if 2 wins $(0, v)$ if no one wins $(0, 0)$	$\Rightarrow (0, 0)$
$\alpha^* = \beta^* \geq 3$	If 1 wins $(v, 0)$ if 2 wins $(0, v)$ if no one wins $(\varepsilon,\varepsilon)$	$\Rightarrow (0, 0)$
$\alpha^* = 0, \beta^* = 1$	If 1 wins $((1-p)v, pv)$ if 2 wins $((1-p)v, pv)$ if no one wins $((1-p)v, pv)$	$\Rightarrow ((1-p)v, pv)$
$\alpha^* = 0, \beta^* = 2$	If 1 wins $(v, 0)$ if 2 wins $((1-p)v, pv)$ if no one wins $(v, 0)$	$\Rightarrow ((1-p)v, 0)$
$\alpha^* = 0, \beta^* > 2$	If 1 wins $(v, 0)$ if 2 wins $(v, 0)$ if no one wins $(v, 0)$	$\Rightarrow (v, 0)$
$\alpha^* = 1, \beta^* = 2$	If 1 wins $(v, 0)$ if 2 wins $(0, (2p-1)v)$ if no one wins $(v, 0)$	$\Rightarrow (2(1-p)v, 0)$
$\alpha^* = 1, \beta^* > 2$	If 1 wins $(v, 0)$ if 2 wins $(v, 0)$ if no one wins $(v, 0)$	$\Rightarrow (v, 0)$
$\alpha^* = 2, \beta^* = 3$	If 1 wins $(v, 0)$ if 2 wins $(0, 0)$ if no one wins $(v, 0)$	$\Rightarrow (v, 0)$
$\alpha^* = 3, \beta^* = 4$	$(v, 0)$	

$$\begin{array}{lcl}
 & \text{If 1 wins } ((1-p)v, pv) & \\
\beta^* = 0, \alpha^* = 1 & \text{if 2 wins } ((1-p)v, pv) & \Rightarrow ((1-p)v, pv) \\
 & \text{if no one wins } ((1-p)v, pv) & \\
 & \text{If 1 wins } ((1-p)v, pv) & \\
\beta^* = 0, \alpha^* = 2 & \text{if 2 wins } (0, v) & \Rightarrow (0, pv) \\
 & \text{if no one wins } (0, v) & \\
\beta^* = 0, \alpha^* \geq 3 & 0, v & \\
 & \text{If 1 wins } (0, (2p-1)v) & \\
\beta^* = 1, \alpha^* \geq 2 & \text{if 2 wins } (0, v) & \Rightarrow (0, v) \\
 & \text{if no one wins } (0, v) & \\
 & \text{If 1 wins } (0, 0) & \\
\beta^* = 2, \alpha^* \geq 3 & \text{if 2 wins } (0, v) & \Rightarrow (0, v) \\
 & \text{if no one wins } (0, v) & \\
\beta^* = 3, \alpha^* \geq 4 & (0, v) &
\end{array}$$

Step 4: $T^* = 4$. By Lemma 1 and Step 3 above, we have:

$T^* = 4, \alpha^*, \beta^*$	$Payoffs$
$\alpha^* = \beta^* = 0$	$((1-p)v, pv)$
$\alpha^* = \beta^* = 1$	If 1 wins $((1-p)v, pv)$ if 2 wins $((1-p)v, pv)$ $\Rightarrow ((1-p)v, pv)$ if no one wins $((1-p)v, pv)$
$\alpha^* = \beta^* = 2$	If 1 wins $(2(1-p)v, 0)$ if 2 wins $(0, v)$ $\Rightarrow (0, (2p-1)v)$ if no one wins $(0, 0)$
$\alpha^* = \beta^* \geq 3$	If 1 wins $(v, 0)$ if 2 wins $(0, v)$ $\Rightarrow (0, 0)$ if no one wins $(0, 0)$
$\alpha^* = 0, \beta^* = 1$	If 1 wins $((1-p)v, pv)$ if 2 wins $((1-p)v, pv)$ $\Rightarrow ((1-p)v, pv)$ if no one wins $(0, 0)$
$\alpha^* = 0, \beta^* = 2$	If 1 wins $((1-p)v, 0)$ if 2 wins $((1-p)v, pv)$ $\Rightarrow ((1-p)v, pv)$ if no one wins $((1-p)v, 0)$
$\alpha^* = 0, \beta^* \geq 3$	If 1 wins $(v, 0)$ if 2 wins $((1-p)v, 0)$ $\Rightarrow (v, 0)$ if no one wins $(v, 0)$
$\alpha^* = 1, \beta^* = 2$	If 1 wins $((1-p)v, 0)$ if 2 wins $((1-p)v, pv)$ $\Rightarrow ((1-p)v, pv)$ if no one wins $(2(1-p)v, 0)$
$\alpha^* = 1, \beta^* = 3$	If 1 wins $(v, 0)$ if 2 wins $(2(1-p)v, 0)$ $\Rightarrow (v, 0)$ if no one wins $(v, 0)$
$\alpha^* = 2, \beta^* = 3$	If 1 wins $(v, 0)$ if 2 wins $(v, 0)$ $\Rightarrow (v, 0)$ if no one wins $(v, 0)$
$\alpha^* = 3$ or $4, \beta^* > \alpha^*$	If 1 wins $(v, 0)$ if 2 wins $(0, 0)$ $\Rightarrow (v, 0)$ if no one wins $(v, 0)$

$$\beta^* = 0, \alpha^* = 1 \qquad \begin{array}{c} \text{If 1 wins } ((1-p)v, pv) \\ \text{if 2 wins } ((1-p)v, pv) \\ \text{if no one wins } ((1-p)v, pv) \end{array} \qquad \Rightarrow ((1-p)v, pv)$$

$$\beta^* = 0, \alpha^* = 2 \qquad \begin{array}{c} \text{If 1 wins } ((1-p)v, pv) \\ \text{if 2 wins } (0, pv) \\ \text{if no one wins } (0, pv) \end{array} \qquad \Rightarrow ((1-p)v, pv)$$

$$\beta^* = 0, \alpha^* \geq 2 \qquad 0, v$$

$$\beta^* = 1, \alpha^* = 2 \qquad \begin{array}{c} \text{If 1 wins } ((1-p)v, pv) \\ \text{if 2 wins } (0, pv) \\ \text{if no one wins } (0, v) \end{array} \qquad \Rightarrow ((1-p)v, pv)$$

$$\beta^* = 1, \alpha^* \geq 3 \qquad \begin{array}{c} \text{If 1 wins } (0, v) \\ \text{if 2 wins } (0, v) \\ \text{if no one wins } (0, v) \end{array} \qquad \Rightarrow (0, v)$$

$$\beta^* = 2, \alpha^* \geq 3 \qquad \begin{array}{c} \text{If 1 wins } (0, 0) \\ \text{if 2 wins } (0, v) \\ \text{if no one wins } (0, v) \end{array} \qquad \Rightarrow (0, v)$$

$$\beta^* = 3 \text{ or } 4, \alpha^* > \beta \qquad \begin{array}{c} \text{If 1 wins } (0, 0) \\ \text{if 2 wins } (0, v) \\ \text{if no one wins } (0, v) \end{array} \qquad \Rightarrow (0, v)$$

Step 5: $T^* = 5$. By Lemma 1 and Step 4 above, we have:

$T^* = 5, \alpha^*, \beta^*$	$Payoffs$	
$\alpha^* = \beta^* = 0$	$((1-p)v, pv)$	
$\alpha^* = \beta^* = 1$	If 1 wins $((1-p)v, pv)$ if 2 wins $((1-p)v, pv)$ if no one wins $((1-p)v, pv)$	$\Rightarrow ((1-p)v, pv)$
$\alpha^* = \beta^* = 2$	If 1 wins $((1-p)v, pv)$ if 2 wins $((1-p)v, pv)$ if no one wins $(0, (2p-1)v)$	$\Rightarrow ((1-p)v, pv)$
$\alpha^* = \beta^* = 3$	If 1 wins $(v, 0)$ if 2 wins $(0, v)$ if no one wins $(0, 0)$	$\Rightarrow (0, 0)$
$\alpha^* = 0, \beta^* = 1$	If 1 wins $((1-p)v, pv)$ if 2 wins $((1-p)v, pv)$ if no one wins $((1-p)v, pv)$	$\Rightarrow ((1-p)v, pv)$
$\alpha^* = 0, \beta^* = 2$	If 1 wins $((1-p)v, 0)$ if 2 wins $((1-p)v, pv)$ if no one wins $((1-p)v, 0)$	$\Rightarrow ((1-p)v, pv)$
$\alpha^* = 0, \beta^* = 3$	If 1 wins $(v, 0)$ if 2 wins $((1-p)v, pv)$ if no one wins $(v, 0)$	$\Rightarrow ((1-p)v, 0)$
$\alpha^* = 1, \beta^* = 2$	If 1 wins $((1-p)v, pv)$ if 2 wins $((1-p)v, pv)$ if no one wins $((1-p)v, pv)$	$\Rightarrow ((1-p)v, pv)$
$\alpha^* = 1, \beta^* = 3$	If 1 wins $(v, 0)$ if 2 wins $((1-p)v, pv)$ if no one wins $(v, 0)$	$\Rightarrow ((1-p)v, 0)$

$$\begin{array}{ccc}
 & \text{If 1 wins } (v,0) & \\
\alpha^* = 2, \beta^* = 3 & \text{if 2 wins } (v,0) & \Rightarrow (v,0) \\
 & \text{if no one wins } (v,0) & \\
 & \text{If 1 wins } (v,0) & \\
\alpha^* = 3 \text{ or } 4, \beta^* > \alpha^* & \text{if 2 wins } (0,0) & \Rightarrow (v,0) \\
 & \text{if no one wins } (v,0) & \\
 & \text{If 1 wins } ((1-p)v, pv) & \\
\beta^* = 0, \alpha^* = 1 & \text{if 2 wins } ((1-p)v, pv) & \Rightarrow ((1-p)v, pv) \\
 & \text{if no one wins } ((1-p)v, pv) & \\
 & \text{If 1 wins } ((1-p)v, pv) & \\
\beta^* = 0, \alpha^* = 2 & \text{if 2 wins } (0, pv) & \Rightarrow ((1-p)v, pv) \\
 & \text{if no one wins } (0, pv) & \\
\beta^* = 0, \alpha^* \geq 2 & 0, v & \\
 & \text{If 1 wins } ((1-p)v, pv) & \\
\beta^* = 1, \alpha^* = 2 & \text{if 2 wins } (0, pv) & \Rightarrow ((1-p)v, pv) \\
 & \text{if no one wins } (0, v) & \\
 & \text{If 1 wins } (0, v) & \\
\beta^* = 1, \alpha^* \geq 3 & \text{if 2 wins } (0, v) & \Rightarrow (0, v) \\
 & \text{if no one wins } (0, v) & \\
 & \text{If 1 wins } (0,0) & \\
\beta^* = 2, \alpha^* \geq 3 & \text{if 2 wins } (0, v) & \Rightarrow (0, v) \\
 & \text{if no one wins } (0, v) & \\
 & \text{If 1 wins } (0,0) & \\
\beta^* = 3 \text{ or } 4, \alpha^* > \beta & \text{if 2 wins } (0, v) & \Rightarrow (0, v) \\
 & \text{if no one wins } (0, v) &
\end{array}$$

We can now proceed to the Induction Hypothesis.

Step 6: Assume that the following holds for all $T^* \leq K$:

If T^* is even:

T^*, α^*, β^*	$Payoffs$
$T < \alpha^*$	$(\varepsilon, \varepsilon)$
$\alpha^* \leq T < \beta^*$	$(v, 0)$
$\beta^* \leq T < \alpha^* + \beta^*$	$\begin{cases} \text{if } \alpha^* = \beta^* & (0,0) \\ \text{otherwise} & (v,0) \end{cases}$
$T = \alpha^* + \beta^*$	$\begin{cases} \text{if } \alpha^* = \beta^* & (0,(2p-1)v) \\ \text{otherwise} & (v,0) \end{cases}$
$\alpha^* + \beta^* < T^* < 2\beta^* - 1$	$(v, 0)$
$T = 2\beta^*, \alpha^* \neq \beta^*$	$((1-p)v, pv)$
$2\beta^* - 1 < T^*$	$((1-p)v, pv)$

If T^* is odd

T^*, α^*, β^*	$Payoffs$
$T^* < \alpha^*$	$(\varepsilon, \varepsilon)$
$\alpha^* \leq T^* < \beta^*$	$(v, 0)$
$\beta^* \leq T^* < \alpha^* + \beta^*$	$\begin{cases} \text{if } \alpha^* = \beta^* & (0,0) \\ \text{otherwise} & (v,0) \end{cases}$
$T^* = \alpha^* + \beta^*$	$\begin{cases} \text{if } \alpha^* = \beta^* - 1 & (2(1-p)v, 0) \\ \text{if } \beta^* = \alpha^* - 1 & (0, v) \\ \text{if } \alpha^* < \beta^* - 1 & (v, 0) \\ \text{if } \beta^* < \alpha^* - 1 & (0, v) \end{cases}$
$\alpha^* + \beta^* < T^* < 2\beta^* - 1$	$(v, 0)$
$T^* = 2\beta^* - 1$	$((1-p)v, 0)$
$2\beta^* - 1 < T^*$	$((1-p)v, pv)$

With one exception above when $T^* = \alpha^* + \beta^*$ and T^* is odd, we have considered only the case of $\alpha^* \leq \beta^*$ which for our main result with $\alpha < \beta$ is the relevant one. That exception aside, the opposite case is analogous.

Step 7: We now prove that the above holds for $T^* = K + 1$.

Suppose that T^* is even:

Case 1: $T^* < \alpha^*$.

Obviously the pay-offs are $(\varepsilon, \varepsilon)$ in this case.

Case 2: $\alpha^* \leq T^* < \beta^*$

Obviously the pay-offs are $(v, 0)$ in this case.

Case 3:$\beta^* \leq T^* < \alpha^* + \beta^*$.

In this case if Player 1 wins pay-offs are $(v, 0)$. If Player 2 wins, pay-offs are either $(v, 0)$ or $(2(1-p)v, 0)$. If no player wins, pay-offs are $(v, 0)$. By Lemma 1, the pay-offs from this game are $(v, 0)$.

Case 4: $T^* = \alpha^* + \beta^*$.

If $\alpha^* = \beta^*$ we have that:

If Player 1 wins pay-offs are $(2(1-p)v, 0)$. If Player 2 wins pay-offs are $(0, v)$. If no player wins, pay-offs are $(0, 0)$.

By Lemma 1, the payoff from this game is $(0, (2p-1)v)$. If $\alpha^* < \beta^*$ we have that: If Player 1 wins pay-offs are $(v, 0)$, if Player 2 wins pay-offs are $(v, 0)$ and if no player wins, pay-offs are $(v, 0)$. By Lemma 1, the payoff from this game is $(v, 0)$.

Case 5: $\alpha^* + \beta^* < T^* < 2\beta^* - 1$. Note that in this case we cannot have $\alpha^* = \beta^*$. So we have $\alpha^* < \beta^*$. If Player 1 wins pay-offs are $(v, 0)$, if Player 2 wins pay-offs are $(v, 0)$ or $((1-p)v, 0)$ and if no player wins, pay-offs are $(v, 0)$. By Lemma 1, the payoff from this game is $(v, 0)$.

Case 6: $2\beta^* - 1 < T^*$: If Player 1 wins pay-offs are $((1-p)v, pv)$ or $((1-p)v, 0)$, if Player 2 wins pay-offs are $((1-p)v, pv)$, and if no player wins, one of the players will get a zero payoff. By Lemma 1, the payoff from this game is $((1-p)v, pv)$.

Suppose now that T^* is odd:

Case 1: $T^* < \alpha^*$

Pay-offs are $(\varepsilon, \varepsilon)$.

Case 2: $\alpha^* \leq T^* < \beta^*$

Pay-offs are $(v, 0)$.

Case 3: $\beta^* \leq T^* < \alpha^* + \beta^*$

If $\alpha^* = \beta^*$: If 1 wins pay-offs are $(v, 0)$, if 2 wins pay-offs are $(0, v)$ and if no one wins pay-offs are $(0, 0)$ so that by Lemma 1 pay-offs in this game are $(0, 0)$.

If $\alpha^* < \beta^*$: If 1 wins pay-offs are $(v, 0)$, if 2 wins pay-offs are $(0, v)$ or $(0, 0)$ and if no one wins pay-offs are $(v, 0)$. Thus by Lemma 1 pay-offs in this game are $(v, 0)$.

Case 4: $T^* = \alpha^* + \beta^*$

If $\beta^* - \alpha^* > 1$, whoever wins leads to $(v, 0)$ and thus pay-offs are $(v, 0)$.

If $\beta^* - \alpha^* = 1$: If 1 wins pay-offs are $(v, 0)$, if 2 wins pay-offs are $(0, (2p-1)v)$ and if no one wins pay-offs are $(v, 0)$. By Lemma 1 pay-offs in this game are $(2(1-p)v, 0)$.

If $\alpha^* - \beta^* > 1$, pay-offs as above are $(0, v)$ whereas if $\alpha^* - \beta^* = 1$, if 1 wins then pay-offs according to the induction hypothesis are (0,0) and otherwise $(0, v)$ and thus continuation pay-offs are $(0, v)$.

Case 5: $\alpha^* + \beta^* < T^* < 2\beta^* - 1$

Note that in this case $\beta^* - \alpha^* > 1$. If 1 wins pay-offs are $(v, 0)$, if 2 wins pay-offs are $(v, 0)$, if no one wins pay-offs are $(v, 0)$. By Lemma 1 pay-offs in this game are $(v, 0)$.

Case 6: $\alpha^* + \beta^* < T^* = 2\beta^* - 1$

Note that in this case $\beta^* - \alpha^* > 1$. If 1 wins pay-offs are $(v, 0)$, if 2 wins pay-offs are $((1-p)v, pv)$, and if no one wins pay-offs are $(v, 0)$. By Lemma 1 pay-offs in this game are $((1-p)v, 0)$.

Case 7: $2\beta^* - 1 < T$: If 1 wins pay-offs are $((1-p)v, pv)$, if 2 wins pay-offs are $((1-p)v, pv)$ and if no one wins pay-offs are $((1-p)v, pv)$. By Lemma 1 pay-offs in this game are $((1-p)v, pv)$.

This concludes the proof.■