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Does Delegation Help to Prevent Spiteful Behavior?

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Christian Rusche[1]

Does Delegation Help to Prevent Spiteful Behavior?

Abstract

The direct evolutionary approach according to Leininger (2003) states that players in a two player Tullock rent-seeking contest within a finite population behave „as if" they were relative payoff maximizers. Accordingly contest expenditures are higher than in Nash equilibrium. The indirect evolutionary approach also predicts more aggressive behavior by the players since negatively interdependent preferences are evolutionary stable. Both players are willing to harm themselves in material terms just to harm their opponent even more. I consider that every player in the contest has to contract a delegate either using a relative contract or a no-win-nopay contract. I show that delegation once introduced is able to overcompensate all negative effects of negatively interdependent objective functions. But as in the case without delegation a commitment on more aggressive behavior is a dominant strategy. Nevertheless delegation endows principals with a material payoff that is equal to the payoff an individualistic player facing another individualistic player would get.

JEL Classification: C72, D72, M52

Keywords: Contest; strategic delegation; spite; agency theory

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1 Introduction

Contests are omnipresent in nature, including human live. Everywhere individuals are investing irreversible efforts in order to have the chance of winning a price. R&D races or the fight between two animals for a piece of food are only two examples. Many articles have been written concerning contests, for an overview see Congleton et. al (2008) and Lockard and Tullock (2001).

In the last years, there has also been an increasing interest into evolutionary perspectives on contests. The idea is that those individuals which are more successful have more resources to raise offspring and therefore become more frequent in the population. One of the first authors using an evolutionary approach in an economic context was Alchian (1950). It took another 24 years before the term Evolutionary Stable Strategy (ESS) was introduced into the literature by Maynard Smith (1974). Smith used a pair-wise contest in an infinite population. In 1988 Schaffer generalized this concept to cover the case of a finite population and more than two contestants. Schaffer called his solution concept generalized ESS. Since then many authors were concerned with determining an evolutionary stable behavior, for example Leininger (2003) and Hehenkamp et. al (2004). An important result of these authors is that spiteful behavior yields an evolutionary advantage in contests. That means that individuals are willing to hurt themselves if the opponents suffer even more. By decreasing the payoffs of the opponents even more than one's own payoff, an individual can be *relatively* more successful and therefore raise more offspring compared to other individuals. Also, full- and even overdissipation of the rent can occur (see Hehenkamp et. al, 2004).

Güth and Yaari (1992) pioneered the examination of the evolution of preferences and how behavior may be affected. They called this an indirect evolutionary approach. Behavior is determined by the preferences of the individual. Only the preference that makes an individual choose appropriate strategies will survive. This means that individuals can not choose their strategy to be relatively more successful as in the direct evolutionary approach but nature chooses the preferences that indirectly determine the behavior in equilibrium. Leininger (2009) showed that in finite populations individualistic payoff maximization is not evolutionary stable. In fact only negatively interdependent preferences survive in a finite population. Additionally Leininger (2009) showed that the direct and indirect evolutionary approach are equivalent in terms of the behavior generated in equilibrium for two player contests. But this development elicits spiteful behavior of the players. In an evolutionarily stable equilibrium every player invests more and has a lower expected return than without other-regarding preferences. Maximizing relative payoffs is a commitment device at the level of preferences that evolves evolutionarily and causes too much effort compared to absolute payoff maximizing behavior.

Maynard Smith (1974) assigned ESS-behavior only to animals, an assumption that is implicitly made in the literature. The question that I address here is: Is there a mechanism in human society that mitigates spiteful behavior even in the presence of "spiteful", i.e. negatively interdependent preferences? The answer being positive, I will show that strategic delegation is able to mitigate spiteful behavior and to make contestants better off compared to absolute payoff maximization. Nevertheless using contracts with higher incentives for the delegate act as a similar commitment device used by the players since this ensures more aggressive behavior by the agent which still is advantageous in the contest. By choosing such contracts material payoffs for the principals fall but delegation is still able to offset the negative effects of other-regarding preferences.
The idea of strategic delegation goes back to Schelling (1960). He pointed out that delegation can serve as a commitment device and can be beneficial for the delegating principal. Many economists have been concerned with delegation since Schelling, for example Fershtman and Judd (1987), Katz (1991), Fershtman and Kalai (1997) and Baik (2007). Wärneryd (2000) showed that delegation by all principals is preferred to competing on one's own behalf by individualistic payoff maximizing principals. The reason is that the prize has to be shared between the principal and her agent, in case of victory. So the incentive for an agent is always lower than for the principal and therefore efforts fall, with

expected payoffs rising.

In order to show the benefits of delegation I use the evolutionary stable negatively interdependent preferences for two player contests identified by Leininger (2009). Two players out of an arbitrary population will compete for a single indivisible prize and they are obliged to hire a delegate who has to compete for them. I use the well-known Tullock Contest-Success-Function (CSF) to determine the winner. The contest has three stages. At the first stage the principals choose the contracts they want to use simultaneously. Subsequently they contract a delegate and they announce the terms of the contract to the other principals and to both delegates truthfully. At the third stage the actual contest between the delegates takes place. A principal has the choice between two kinds of contracts. The first one offers a share of the prize to incentivize the delegate. Such contracts were used before in the literature, for example by Baik and Kim (1997) or Baik (2007). The second type consists of a payment that is made conditional on the relative success of the agent in the contest. Both delegates are not involved in the conflict before they are contracted and maximize their individualistic payoff. I will show that both contracts make the principals at least as successful as players that maximize their absolute payoff in a setting without delegation. If the agent is paid according to relative success, the principal has to pay a fixum to hire an agent. But a prisoners' dilemma-like game-structure will prevent moral hazard in the relationship between agent and principal.

The paper is organized as follows. First of all I will recall the equilibrium outcomes without delegation within a population of absolute and relative payoff maximizing players as a benchmark in Section 2. In Section 3 I will set up the model with both kinds of contracts. The contract choice game is solved in Section 4 before section 5 concludes.

2 Rent-seeking without delegation

This paper examines Tullock's (1980) contests with two opponents within a population of N individuals, with $2 \leq N < \infty$. Both opponents invest irreversible effort to win the indivisible prize V. The valuation is the same for both. Since no delegation takes place we have only one stage. The winner is determined using the common Tullock Contest-Success-Function (CSF) with $r = 1$ (constant marginal efficiency of effort as Guse and Hehenkamp, 2006, called it). Accordingly the probability of player i, $i \in \{1, 2\}$, winning the prize is given by

$$p_i = \begin{cases} \frac{x_i}{x_i + x_{-i}} & \text{for } x_i + x_{-i} > 0 \\ \frac{1}{2} & \text{for } x_i + x_{-i} = 0. \end{cases}$$

2.1 Absolute payoff maximizing

Every principal strikes for her own benefit, independently of population size and outcomes for the other players. Correspondingly the expected utility of player i is given by

$$\pi_i = \frac{x_i}{x_i + x_{-i}} V - x_i.$$

Deriving the first order condition for player i yields

$$\frac{\partial \pi_i}{\partial x_i} = \frac{x_{-i}}{(x_i + x_{-i})^2} V - 1 \stackrel{!}{=} 0.$$

In equilibrium we get

$$x_1 = x_2 = \frac{V}{4}$$
$$\pi_1 = \pi_2 = \frac{V}{4} = \pi.$$

Nevertheless absolute payoff maximizing is not evolutionary stable as is shown in the following subsection.

2.2 Relative payoff maximizing principals

To show why it is beneficial for individuals to act as if they were relative payoff maximizers in the direct evolutionary I refer to Schaffer (1988). Two players out of an arbitrary population of size N are drawn into contest. $N-1$ players are playing the evolutionary stable strategy x^{ESS} and one single player (a mutant) is playing a different strategy x^M. Therefore with probability $\frac{1}{N-1}$ an ESS-player meets the mutant in the contest.
The corresponding payoff for the mutant is

$$\pi_M = \frac{x^M}{x^M + x^{ESS}} V - x^M.$$

But an ESS-player's expected payoff is given by

$$\begin{aligned}\pi_{ESS} &= \left(1 - \frac{1}{(N-1)}\right) \frac{x^{ESS}}{2x^{ESS}} V - \left(1 - \frac{1}{(N-1)}\right) x^{ESS} \\ &+ \frac{1}{(N-1)} \frac{x^{ESS}}{x^M + x^{ESS}} V - \frac{1}{(N-1)} x^{ESS}.\end{aligned}$$

As Schaffer (1988) points out the equilibrium condition for x^{ESS} being an evolutionary stable strategy is

$$\pi_M \leq \pi_{ESS} \quad \text{, for any strategy } x^M.$$

If the mutant is chosen to participate in the conflict she has to solve the following problem

$$\begin{aligned}&\max_{x^M} \quad \pi_M - \pi_{ESS} \\ \Rightarrow &\max_{x^M} \quad \left\{ \frac{x^M}{x^M + x^{ESS}} V - x^M - \frac{1}{(N-1)} \frac{x^{ESS}}{x^M + x^{ESS}} V + \frac{1}{(N-1)} x^{ESS} \right\}.\end{aligned}$$

The solution of the given problem is $x^M = x^{ESS}$ and the corresponding maximum is zero. The stability condition used by Schaffer (1988) is omitted here because of simplicity.
In contrast to an absolute payoff maximizer both players act as if they were concerned with a weighted relative payoff in an evolutionary stable equilibrium. This weighted relative payoff is identical to their relative payoffs if $N = 2$. In an evolutionary context absolute

payoff is not the main criterion to measure the fitness of an individual. Relative payoff is important because an individual wants to raise more offspring than the opponents and not just more offspring. This gives way for the development of spiteful behavior. An individual hurts herself just to hurt the opponent even more, a point already mentioned by Hamilton (1970). This behavior at the level of strategies in the direct evolutionary approach can be shown to be reproduced at the level of preferences in the indirect evolutionary approach (see Leininger, 2009). If players are direct payoff maximizers, they are driven to maximize nagatively interdependent preferences in the evolutionarily stable preferences.

Accordingly, the utility function of an arbitrary player j, $j \in \{1, 2\}$, is now given by the evolutionarily stable preferences as indentified in Leininger (2009).

$$u_j = \frac{y_j}{y_j + y_{-j}} V - y_j - \frac{1}{(N-1)} \frac{y_{-j}}{y_j + y_{-j}} V + \frac{y_{-j}}{(N-1)}.$$

By deriving the first order conditions we get

$$y_j = y_{-j} = \frac{N}{(N-1)} \frac{V}{4}.$$

Since the winning probability is $\frac{1}{2}$ for all players, the material payoff of any player is

$$\pi_R = \frac{(N-2)}{4(N-1)} V,$$

the corresponding weighted relative payoff is

$$u_R = \frac{(N-2)^2}{4(N-1)^2} V.$$

Note that we have full dissipation if $N = 2$ as both players then maximize relative payoffs. But for N approaching infinity the evolutionarily stable utility function converges to the individualistic payoff function. As N increases the concern for the payoffs of the other

players gets smaller and smaller, because only one rival can be hurt and $N-2$ players remain unaffected by the contest. Accordingly, as can be seen from the above formulas $u_R = \pi_R = \pi$ from section 2.1 for N approaching infinity. But for smaller N $\pi > \pi_R$.
Suppose that we have a population of individualistic players as starting point. Due to mutations an other-regarding player occurs. The mutant acts more aggressively and as a consequence hurts her opponent acting individualistic more than she hurts herself in material terms. Accordingly she has a higher material payoff and is more successful in evolutionary terms compared to her opponent. In the end the whole population is made up of other-regarding players because the mutation mentioned above has more resources to spent and is therefore supposed to be more successful in reproducing herself. According to that development the invested efforts grow but since we are in a symmetric situation the winning probability remains unchanged and therefore the material payoffs fall compared to the situation before the mutation occured.

3 The Model

Now I turn towards contests with mandatory delegation. Both principals have negative interdependent preferences. It is worth mentioning that this also ensures participation by the principals: The individuals experience negative utility if they do not invest, since the opponent wins for sure. The game has three stages. At the first stage both principals choose a contract each simultaneously. At stage II the principals contract a delegate. The contract is announced to the other principal truthfully. Subsequently at stage III both delegates engage in the contest and exert effort. Finally the winner is determined and the prize is handed out. Both principals can choose between two types of contracts: No-win-no-pay contracts and relative contracts.
First of all, I examine the model with both principals using no-win-no-pay contracts. The delegate obtains a part of the prize but only in case of victory. Thereafter the model is defined with a payment to delegates according to the relative success of the delegate. The idea behind that contract is that the other-regarding preferences of a principal might

induce "other-regarding" contracts with the corresponding delegate. Subsequently I examine the asymmetric case, namely one principal using a no-win-no-pay contract and the other one is rewarding her agent according to relative success.

In all cases the efforts invested by a delegate are denoted by d. A subsript indicates the principal the delegate is working for. A superscript refers to the case under examination.

3.1 No-win-no-pay contracts

Baik (2007) showed that it is optimal to use no-win-no-pay contracts for absolute payoff maximizing principals if they have to hire a delegate. Only if the contest is won, the agent will get a share of the contested prize. I will denote the share principal l is using as an incentive by α_l, with $\alpha_l \in [0,1]$ and $l \in \{1,2\}$. I exclude the possibility of reselling the right to participate to another agent. If the right is sold, no delegation would take place, just the principal is changed. I also exclude negative amounts as a fixed part of compensation because a fixed payment does not change the behavior of the delegate and therefore the equilibrium strategies. I will also show that delegation with no-win-no-pay contracts is beneficial for a principal even without a negative fixed payment for the delegate.

The utility function of principal l is given by

$$u^A_{Pl} = \frac{d^A_l}{d^A_l + d^A_{-l}}(1-\alpha_l)V - \frac{1}{(N-1)}\left(\frac{d^A_{-l}}{d^A_l + d^A_{-l}}\right)(1-\alpha_{-l})V.$$

The first term stands for the material payoff the principal gets. She does not have to bear any effort cost directly. On account of this she gets only the remaining share of the contested prize. The second term reflects the principal's concern for her relative position. It is the material payoff of her opponent weighted with $\frac{1}{N-1}$. Note that the opponent principal also has to choose an agent.

Her delegate is paid according to the following payoff function:

$$\pi^A_{Dl} = \frac{d^A_l}{d^A_l + d^A_{-l}}\alpha_l V - d^A_l.$$

The reservation wage of the delegate is normalized to zero, but as long as the expected payoff for the delegate is negative, no rational agent will sign this contract. We solve the model by backward induction, starting with stage III. For determining the optimal effort, we have to derive the first order conditions

$$\begin{aligned}\frac{\partial \pi_{D1}^A}{\partial d_1^A} &= \frac{d_2^A}{(d_1^A + d_2^A)^2}\alpha_1 V - 1 \overset{!}{=} 0,\\ \frac{\partial \pi_{D2}^A}{\partial d_2^A} &= \frac{d_1^A}{(d_1^A + d_2^A)^2}\alpha_2 V - 1 \overset{!}{=} 0.\end{aligned}$$

Solving these equations for d_1^A and d_2^A, we obtain

$$\begin{aligned}d_1^A &= \frac{\alpha_1^2\alpha_2}{(\alpha_1+\alpha_2)^2}V,\\ d_2^A &= \frac{\alpha_1\alpha_2^2}{(\alpha_1+\alpha_2)^2}V.\end{aligned}$$

Hence the winning probability for any principal l is

$$p_l^A = \frac{\alpha_l}{\alpha_l + \alpha_{-l}}.$$

I continue with analyzing the second stage. A principal chooses the offered share α_l such that she maximizes her utility

$$\max_{\alpha_l} \quad \left\{ u_{Pl}^A = \frac{\alpha_l - \alpha_l^2}{\alpha_l + \alpha_{-l}}V - \frac{1}{(N-1)}\frac{\alpha_{-l} - \alpha_{-l}^2}{\alpha_l + \alpha_{-l}}V \right\}.$$

Focusing on a symmetric equilibrium, let $\alpha_1 = \alpha_2 = \alpha$. The first order condition of any of the principals reduces to

$$\alpha - 3\alpha^2 + \frac{1}{(N-1)}(\alpha - \alpha^2) = 0$$

Solving this for α, we obtain

$$\alpha = \frac{N}{(3N-2)}.$$

$\alpha = 0$ is omitted here as a solution. The chosen α of an other-regarding player is $\frac{1}{2}$ for $N = 2$ and converges to $\frac{1}{3}$ for N converging to infinity. An absolute payoff maximizing player in an infinite population would use one third of the contested prize to incentivize her delegate. Therefore we can state that an other-regarding player will incentivize her delegate more heavily than an absolute payoff regarding principal and therefore acts spiteful if the contest is played in a finite population.

We have established:

Lemma 1: *The utility of the principals in equilibrium is given by*

$$u^A_{P1} = u^A_{P2} = \frac{(N-2)}{(3N-2)}V = u^A.$$

The underlying material payoff that determines the fitness of the principals in evolutionary terms is

$$\pi^A_{P1} = \pi^A_{P2} = \frac{(N-1)}{(3N-2)}V = \pi^A_P.$$

A delegate in this conflict has an equilibrium payoff of

$$\pi^A_D = \frac{N}{4(3N-2)}V = \frac{\alpha V}{4}.$$

The material payoff of both principals is positive for any value of N, though they experience zero utility for $N = 2$.

Note that $\pi^A_P > \pi_R$ and $\pi^A_P > \pi$ for $N > 2$ therefore delegation is beneficial for the principals in material terms because the winning probability remains unchanged since we are in a symmetric equilibrium and the expenditures in the contest are reduced. By introducing delegation with no-win-no-pay contracts the prize has to be splitted up between agent and principal. Accordingly the incentives for a delegate to exert effort and for a principal to stimulate the agent are always lower than without delegation. Also exerting effort becomes more expensive because the principal has to pay the delegate to invest more but only a fraction of this extra incentive is also expended. The reason for that is that the expected payoff for a delegate is non-negative because α is assumed to be non-negative. This result is in line with Baik (2007) who predicted positive profits in the "delegate industry" for contests between absolute payoff maximizing principals. As in the article by Baik positive profits are due to strategic decisions by the principals. The principals try to put their agents into a similar situation they would be in without delegation. This is achieved by using αV as prize in a new contest played by the delegates. According to Section 2.1 the absolut payoff maximizing behavior of the delegates leads to positiv profits for them.

3.2 Relative contracts

We now turn towards the case of relative contracts. Both principals pay their agent depending on their relative success in the conflict. Let β_l, with $\beta_l \geq 0$ and $l \in \{1, 2\}$, multiplied with the relative success as measured by the difference in winning probabilities of agent l represent the delegate's payment.

That means if any delegate succeeds in achieving a higher winning probability than the other delegate by using her effort then she will be considered to be more successful and therefore be rewarded. Note that a delegate will be punished if her opponent outperforms her.

It is forbidden to sell the right of participation again, but it is possible to pay a fixed amount F to the delegate to meet her participation constraint. That means an agent gets a fixed amount even if the contest is lost and a relative payment (which may be negative) but has to pay her invested effort. A principal has to pay the fixed amount and the relative payment but she earns the contested prize if her agent is successful.

Again, beginning with the analysis of stage III, we have to determine the equilibrium efforts depending on β_l. Therefore we start with the payoff function of delegate l

$$\pi^B_{Dl} = \beta_l \left(\frac{d^B_l}{d^B_l + d^B_{-l}} - \frac{d^B_{-l}}{d^B_l + d^B_{-l}} \right) V - d^B_l + F^B_l.$$

By deriving both delegate's first order condition and by setting them equal, we get

$$d^B_1 \beta_2 = d^B_2 \beta_1.$$

Using this relationship for determining the optimal efforts and probabilities yields

$$\begin{aligned} d^B_l &= \frac{2\beta_l^2 \beta_{-l}}{(\beta_l + \beta_{-l})^2} V, \\ p^B_l &= \frac{\beta_l}{\beta_l + \beta_{-l}}. \end{aligned}$$

At stage II, any principal l maximizes

$$\begin{aligned} \pi^B_{Pl} &= \frac{\beta_l}{\beta_l + \beta_{-l}} V - \beta_l \left(\frac{\beta_l}{\beta_l + \beta_{-l}} - \frac{\beta_{-l}}{\beta_l + \beta_{-l}} \right) V - F_l \\ &- \frac{1}{(N-1)} \left(\frac{\beta_{-l}}{\beta_l + \beta_{-l}} V - \beta_{-l} \left(\frac{\beta_{-l}}{\beta_l + \beta_{-l}} - \frac{\beta_l}{\beta_l + \beta_{-l}} \right) V - F_{-l} \right). \end{aligned}$$

As before the payoff function of the principal consists of the own material payoff and the material payoff of the opponent weighted with the remaining share of the population this opponent represents. The material payoff is comprised of the fixed and the relative payment to the delegate as well as the contested prize if the contest is won.

The first order condition for player 1 is given by

$$\begin{aligned} \frac{\partial \pi^B_{P1}}{\partial \beta_1} &= \frac{\beta_2}{(\beta_1 + \beta_2)^2} V - \frac{2\beta_1(\beta_1 + \beta_2) - \beta_1^2}{(\beta_1 + \beta_2)^2} V \\ &+ \frac{\beta_2(\beta_1 + \beta_2) - \beta_1 \beta_2}{(\beta_1 + \beta_2)^2} V + \frac{1}{(N-1)} \frac{\beta_2}{(\beta_1 + \beta_2)^2} V \\ &- \frac{1}{(N-1)} \frac{\beta_2^2}{(\beta_1 + \beta_2)^2} V - \frac{1}{(N-1)} \frac{\beta_2(\beta_1 + \beta_2) - \beta_2 \beta_1}{(\beta_1 + \beta_2)^2} V \overset{!}{=} 0. \end{aligned}$$

Using symmetry we can solve this condition for β^*:

$$\beta^* = \frac{1}{2}.$$

I have omitted $\beta^* = 0$. In equilibrium both principals offer their delegate one half of the prize weighted with the difference in the winning probability they achieved as compensation. Notice that, since we are in a symmetric equilibrium, the relative payment to the agent is zero because no delegate is more successful than the other one. Her payoff would be negative and no rational agent would ever sign this contract without a fixed amount as compensation. Therefore the fixed amount is used to meet the participation constraint of an agent. The only meaningful amount is $F = d$. That means the principal pays the equilibrium effort. But why should a delegate invest something when the fixed amount is paid anyway? This problem is solved by a kind of prisoners' dilemma that both agents are in. Suppose that both do not invest any effort. They will get their compensation

$$F_1 = F_2 = \frac{V}{4}.$$

But what happens if the agent of player l deviates and invests an infinitively small, positive amount ε and the other one invests nothing? The deviating agent would not only get the fixed payment but also a relative payment because she is more successful than the "lazy" delegate. Therefore she would get

$$\pi_{Dl} = \frac{3}{4}V - \varepsilon$$

and the other agent would lose! This amount is strictly larger than F. Therefore we can see that an agent wants to deviate by investing effort. In contrast to no-win-no-pay contracts both agents earn a material payoff of zero in equilibrium.

We have seen that a principal pays indirectly for the effort. She offers a contract and raises the fixed amount until an agent's participation contraint is met. By using relative contracts in a contest with two players out of a population of N where the players have to delegate, we get

Lemma 2: *The utility of the principals in equilibrium with relative contracts is given by*

$$u^B_{P1} = u^B_{P2} = \frac{(N-2)}{(N-1)}\frac{V}{4} = u^B.$$

In material terms each principal has a payoff of

$$\pi^B_{P1} = \pi^B_{P2} = \frac{V}{4} = \pi^B.$$

We can see that the material payoff is positive although a principal might experience a utility of zero.

Note that $\pi^B_P < \pi^A_P$ for $N > 2$ and $\pi^B_P = \pi^A_P$ for $N = 2$. What makes the result more striking is that I excluded negative fixed payments in the no-win-no-pay contract case. Therefore we face positive profits there. But in the case with relative contracts I assumed that the fixed payment is only used to endow the delegate with zero utility.

Due to the introduction of relative contracts the effects of delegation with no-win-no-pay contracts are partly reversed and any principal as well as her corresponding delegate act more aggressively. The reason for that is that the only way for a delegate to get a positive profit is to get ahead of the other delegate. Hence any agent is incentivized to invest more effort. This is analogue to the situation the principals are in since they are also concerned with maximizing relative payoffs which makes them more aggressive. But since $\beta^* = \frac{1}{2}$ the prize for the delegate is smaller than for a principal and accordingly she acts not as aggressively as a principal would do in a situation without delegation. Thus delegation with relative contracts is beneficial compared to a situation without delegation.

3.3 Asymmetric case

In this case one principal is using a no-win-no-pay contract and the other one rewards her delegate according to the relative success her agent achieves. Without loss of generality I assume that principal 1 uses a no-win-no-pay contract and principal 2 uses a relative contract. Let $\alpha \in [0, 1]$ denote the share of the contested prize that principal 1 offers her agent. And let $\beta \geq 0$ be the corresponding factor the second principal uses. F^C is the fixed payment used by the second principal.

Starting at stage III, the payoff functions of the delegates are

$$\pi^C_{D1} = \frac{d_1}{d_1 + d_2}\alpha V - d_1$$
$$\pi^C_{D2} = F^C + \left(\frac{d_2 - d_1}{d_1 + d_2}\right)\beta V - d_2.$$

Using both first order conditions to determine the efforts in equilibrium yields

$$d^C_1 = \frac{2\alpha^2\beta}{(\alpha + 2\beta)^2)}V$$
$$d^C_2 = \frac{4\alpha\beta^2}{(\alpha + 2\beta)^2}V.$$

And therefore the equilibrium winning probabilities are

$$p^C_1 = \frac{\alpha}{\alpha + 2\beta}$$
$$p^C_2 = \frac{2\beta}{\alpha + 2\beta}.$$

Principal 1 then maximizes

$$\pi^C_{P1} = \frac{(\alpha - \alpha^2)}{(\alpha + 2\beta)}V - \frac{2\beta}{(\alpha + 2\beta)}\frac{V}{(N-1)} + \left(\frac{(2\beta - \alpha)}{(\alpha + 2\beta)}\right)\frac{\beta V}{(N-1)} - \frac{F^C}{(N-1)}.$$

Using this first order condition to compute the reaction function of principal 1 yields

$$\alpha = -2\beta + \sqrt{\frac{4\beta^2(N-2) + 2\beta N}{(N-1)}}. \quad (1)$$

Since $\alpha \in [0,1]$, I excluded $-2\beta - \sqrt{\frac{4\beta^2(N-2)+2\beta N}{(N-1)}}$ as a solution.

The corresponding reaction function of principal 2 is given by

$$\beta = -\frac{\alpha}{2} + \sqrt{\frac{(N-2)\alpha^2 + \alpha N}{(N-1)}}. \tag{2}$$

Apparently $\alpha = \beta = 0$ is an intersection point of both reaction curves but with mandatory delegation this is not an equilibrium since both principals have an incentive to deviate. It is rather difficult to find the equilibrium analytically. But for my further analysis it is not necessary to know the exact answer. It is possible to state the following:

Lemma 3: *The principal using a no-win-no-pay contract will choose an $\alpha \leq \frac{1}{2}$ in equilibrium if she has to deal with a principal using a relative contract, whatever value β and N are.*

Proof: To show that the highest α a rational principal chooses in the described situation is smaller or equal than $\frac{1}{2}$ I use the reaction function of principal 1. The following must hold true

$$\frac{1}{2} \geq \alpha = -2\beta + \sqrt{\frac{4\beta^2(N-2) + 2\beta N}{(N-1)}}.$$

Which can be rewritten as

$$(N-1)(\frac{1}{2} + 2\beta)^2 \geq 4\beta^2(N-2) + 2\beta N.$$

After doing some rearrangement we get

$$\frac{1}{4}N + 4\beta^2 \geq \frac{1}{4} + 2\beta.$$

For $N \geq 3$ the left side is greater since $\beta > 0$. In contrast for $N = 2$ both sides are equal if $\beta = 0,25$ but for any other value of β the left side is greater. Therefore we can state that the inequality holds true, whatever value β and N are.

■

It is also worthwile to have a look at the equilibrium payoff for the delegate of principal 2:

$$\pi_{D2}^{C} \; = \; \left(\frac{(2\beta-\alpha)}{(\alpha+2\beta)}\right)\beta V - \left(\frac{4\alpha\beta^2}{(\alpha+2\beta)^2}\right)V + F^c.$$

Using the reaction functions just derived above, we can show

Lemma 4: *Principal 2 does not have to use a fixed payment to attract a delegate and therefore* $F^C = 0$.

Proof: Principal 2 does not have to pay a fixed amount if the payoff for her agent is positive even without this transfer. We have to show the following

$$\frac{(2\beta-\alpha)}{(\alpha+2\beta)}\beta V - \frac{4\alpha\beta^2}{(\alpha+2\beta)^2}V \; \geq \; 0.$$

We get

$$2\beta - \alpha^2 - 2\alpha^2 \; \geq \; 0.$$

Applying (2) yields

$$2N + ((1+\sqrt{2})^2 - 4)\alpha \; \geq \; ((1+\sqrt{2})^2 - 2)\alpha N.$$

Since $((1+\sqrt{2})^2 - 4)\alpha > 0$ we can omit it for the moment to concentrate on

$$2N \; \geq \; ((1+\sqrt{2})^2 - 2)\alpha N.$$

This is true for $\alpha \leq \frac{2}{1+2\sqrt{2}}$. Lemma 3 showes that this condition is satsfied. Therefore the expected payoff for the delegate is positive.

■

The incentives for the delegate of principal 2 due to the relative contract are so strong that her invested effort is high enough to make the according relative payment sufficient to pay for her effort. If player 1 wants to incentivize her delegate in a similar way she would have to offer more than $\frac{2}{1+2\sqrt{2}}V$ as a prize for the delegate, which is ruled out by her reaction function.

4 Equilibrium in the contract choice game

Summing up the results derived in Section 3 we get the following normal form game.

		Principal 2	
		NW	RC
Principal 1	NW	u^A, u^A	u^C_{P1}, u^C_{P2}
	RC	u^C_{P2}, u^C_{P1}	u^B, u^B

Where NW stands for no-win-no-pay contracts and RC for relative contracts.

I now show that

Theorem 1: *If two players out of a population consisting of* $2 \leq N < \infty$ *individuals with negatively interdependent preferences are drawn into a contest with mandatory delegation the unique Nash Equilibrium is given by (RC, RC).*

Proof: It has to be shown that using a relative contract is the dominant strategy. Therefore the following must hold

(i) $u^C_{P2} > u^A$ and

(ii) $u^B > u^C_{P1}$.

(i) Using a relative contract is the best response to a no-win-no-pay contract.

That means

$$\frac{2\beta}{(\alpha+2\beta)}V - \frac{(2\beta-\alpha)}{(2\beta+\alpha)}\beta V - \frac{(\alpha-\alpha^2)}{(\alpha+2\beta)}\frac{V}{(N-1)} \quad > \quad \frac{(N-2)}{(3N-2)}V.$$

Using (2) yields

$$
\begin{aligned}
& (3N-2)(N-1)\left(-\frac{\alpha}{2}+\sqrt{\frac{(N-2)\alpha^2+\alpha N}{(N-1)}}\right)\left(2+2\alpha-2\sqrt{\frac{(N-2)\alpha^2+\alpha N}{(N-1)}}\right) \\
> \ & (N-1)(N-2)2\sqrt{\frac{(N-2)\alpha^2+\alpha N}{(N-1)}}+(3N-2)(\alpha-\alpha^2).
\end{aligned}
$$

Which can be rewritten as

$$
\begin{aligned}
& \sqrt{\frac{(N-2)\alpha^2+\alpha N}{(N-1)}}(9\alpha+4)(N-1)\left(N-\frac{6\alpha}{9\alpha+4}\right) \\
> \ & 9\alpha(\alpha+1)(N-\frac{2}{3})\left(N-\frac{2\alpha}{\alpha+1}\right).
\end{aligned}
$$

After doing some rearrangement we get

$$
16N^3+81\alpha^2N^2+12\alpha N+36\alpha^2 \quad > \quad 108\alpha^2N+9\alpha N^3+12\alpha N^2+16N^2.
$$

To show that the left hand side is greater than the right hand side I will define the function $f:\ \mathbb{R}\in[0;\frac{1}{2}]\ \times\ \mathbb{N}\geq 2\ \rightarrow \mathbb{R}$ that accounts for the difference between both sides:

$$
f(\alpha,N) \quad = \quad 16N^3-9\alpha N^3+81\alpha^2N^2-16N^2-12\alpha N^2+12\alpha N-108\alpha^2N+36\alpha^2.
$$

Of course this function is continously and twice differentiable.

As long as this function is greater than zero the condition mentioned above is fullfilled. We can see that f is indeed greater than zero for any $\alpha\in[0;\frac{1}{2}]$ if $N=2$ and if $N\rightarrow\infty$. At first glance it is not clear what happens in between. On that account we have a look on the first derivative with respect to N

$$
\frac{\partial f(\alpha,N)}{\partial N} \quad = \quad 48N^2-27\alpha N^2+162\alpha^2N-32N-24\alpha N+12\alpha-108\alpha^2.
$$

If the first derivative is positive than also f is positive. Since we are starting at a positive value and the function is increasing.

Obviously the first derivative is also positive for $N = 2$ and $N \to \infty$ for any $\alpha \in [0; \frac{1}{2}]$. To demonstrate that the first derivative is also increasing in N I use the second derivative

$$\frac{\partial^2 f(\alpha, N)}{\partial^2 N} = 96N - 54\alpha N + 162\alpha^2 - 32 - 24\alpha.$$

For any value of $\alpha \in [0; \frac{1}{2}]$ the second derivative is positive if $N \geq 0$. That means the first derivative is an increasing function in the domain and it also starts at a positive value.

Using the same argument for f we can conclude that the difference is positive.

(ii) For any principal it has to be beneficial to react with a relative contract to an opponent using a relative contract. Therefore

$$\frac{(N-2)}{(N-1)}\frac{V}{4} > \frac{(\alpha-\alpha^2)}{(\alpha+2\beta)}V - \frac{2\beta}{\alpha+2\beta}\frac{V}{(N-1)} + \frac{(2\beta-\alpha)}{(\alpha+2\beta)}\frac{\beta V}{(N-1)},$$

which leads to

$$2\beta N + 4\alpha^2 N + 2\alpha + 4\beta + 4\alpha\beta > 3\alpha N + 4\alpha^2 + 8\beta^2.$$

Since $2\alpha \geq 4\alpha^2$ as shown by lemma 3 it will be omitted for the moment.

To ease my further analysis I split the problem. If each term on the left side is greater or equal than the corresponding term on the right side and one term is strictly greater then the sum of the left side will also be greater.

We get

- $4\beta + 4\alpha\beta \geq 8\beta^2$ and
- $2\beta N + 4\alpha^2 N > 3\alpha N$.

We can see that both conditions are fullfilled for $N \geq 2$ if we recall that $0 < \alpha \leq \frac{1}{2}$ and if we use (2) to substitute β.

■

Now that the equilibrium in the contract choice game has been revealed I turn towards the respective material payoffs. Assuming that no delegation has been introduced, a player would receive a material payoff of $\pi = \frac{V}{4}$ if she were in a world of absolute payoff maximizers. In contrast to $\pi^R = \frac{N-2}{4(N-1)}V$ if there were only relative payoff maximizers. Maximizing weighted relative payoff is evolutionary stable as shown by Leininger (2009). For comparison I refer to the first case. The reason for that is that I want to point out that delegation is able to offset all negative effects of other-regarding preferences. That means I will show that delegation is able to endow the principals with as much material payoff as simple payoff maximization by all players would do.

Recall the equilibrium payoff of the independent payoff maximizing contest without delegation,

$$\pi = \frac{V}{4}.$$

Delegation is introduced, now. The unique equilibrium is given by both principals using relative contracts. The respective outcome for the principal is as follows

$$\pi_B = \frac{V}{4}$$

We can immediately state:

Theorem 2: *Two randomly chosen players out of a population of absolute payoff maximizing players of arbitrary size drawn to play the described contest earn the same material payoff in equilibrium as two randomly chosen players out of a population of other-regarding players of arbitrary size that are chosen to play a corresponding contest by contracting delegates both using relative contracts.*

■

This is also true for two player contests with $r \leq 1$ and for contests between more than 2 principals and $r = 1$. The latter case is shown in the appendix. The first one is straightforward and therefore omitted.

By using a relative contract a principal is able to establish a situation with independent payoff maximizing individuals engaging in a contest. The reason for this is the symmetry of the opponents. Symmetry cancels out the relative payment for the delegates. Therefore the material payoff function reduces to

$$\pi^B_{Pl} = \frac{d^B_l}{d^B_l + d^B_{-l}} - F^B_l.$$

We have seen that a principal pays the effort indirectly, i.e. $F^B_l = d^B_l$. All that remains is the well known payoff function for a contest of absolute payoff maximizing players Tullock (1980) used. The only difference is that the efforts are exerted by the delegates. The material payoff for any delegate is zero because no principal is willing to pay more in equilibrium since this is the lowest value for which the participation constraint is met.

We have seen in Section 3.2 that no-win-no-pay contracts yield a higher monetary payoff, if $N \geq 2$ compared to absolute payoff maximizing behavior without delegation and delegation with relative contracts. By the introduction of delegation with no-win-no-pay contracts the negative effects of maximizing relative payoffs is completely internalized and even overcompensated for populations with more than two individuals.
Accordingly both principals would prefer a situation without relative contracts. But in the manner of interdependent preferences in contests without delegation also interdependent contracts in contests with delegation have a strategic advantage as we have seen in 3.3. Once relative contracts are introduced or have developed it is the dominant strategy for both principals to use them. By using this kind of contracts the delegates can be incentivised more heavily and therefore they act more aggressively which gives them an advantage compared to less incentivised opponents. This behavior can also be called spiteful. Briefly speaking principals are in a prisoners' dilemma. Nevertheless they have a higher absolute payoff than without delegation. In fact the spiteful behavior according to the maximization of relative payoffs is completely internalized and principals are endowed

with the same material payoff an individualistic player would get if she had to play the contest against another individualistic player.

5 Conclusion

The question I tried to answer was: Are there mechanisms to reduce competition and therefore wasteful investments in rent-seeking-contests when preferences are spiteful? To this end this paper explored the effects of delegation in a Tullock rent-seeking contest when players maximize weighted relative payoff. In a population of individualistic players a certain type of other-regarding player has an advantage. She acts more aggressively and therefore harms the opponent in material terms even more than she hurts herself in the direct contest and also obtains higher material payoff than other individuals in the population. Accordingly being also an other-regarding player is beneficial in evolutionary terms. Through natural selection weighted relative payoff maximizing players become more frequent and in the end the whole population is made up by such players. But this is spiteful because maximizing the relative position in the population leads to higher efforts and reduces the material outcome for every player.

It is shown that in this situation delegation makes the players better off in a two player Tullock contest. I assume that the contest is played within an arbitrary population. By prescribed delegation every player can do at least as well as if she were in a population of payoff maximizing players only. I.e. the evolutionarily imposed "spiteful" preferences get "neutralized" in the contract game. No-win-no-pay contracts are even able to overcompensate the negative effects of relative payoff maximizing behavior. But since interdependent preferences yield an advantage in rent-seeking contests with contracts that reward the delegate according to her relative success, those develop and are used by the principals. This reduces the efficiency gained by the introduction of delegation with no-win-no-pay contracts. However, compared to a population of individualistic players the efficiency is completely restored. In essence, the economic institution of contracting delegates can completely offset the inefficiency caused by natural evolutionary forces at the

preference level, which drive players to hold "spiteful" preferences. In theory, delegation could do even better, but is held back by the same competitive evolutionary forces at the contracting level. More aggressive contracts drive out more moderate ones.
It is shown that there exists a fixed amount the principal has to pay to hire a delegate in the equilibrium of the contract choice game. The fixed amount does not alter the invested effort but is necessary to make an agent willing to sign a contract. A game-structure like in a prisoners' dilemma prevents the delegate from acting as a free-rider.

Mandatory delegation has been assumed. The consequences of relative payoff maximizing players on the terms of contract have been shown. But it is interesting to ask whether prescribed delegation leads to changes in evolutionary stable strategies and preferences. Of importance is also the question after evolutionary stable preferences within contests between more than two opponents.

6 Appendix

6.1 Equilibrium with $n \leq N$ participants and $r = 1$

If $2 \leq n \leq N$ absolute payoff maximizing players play the contest the material payoff according to Tullock (1980) is

$$\frac{V}{n^2}.$$

Now, let n players out of an arbitrary population of N individuals with other-regarding preferences play the contest again. All have to hire a delegate that competes for them. In order to solve the game, I consider two kinds of principals. One of type s and $n-1$ of type t. This can be interpreted as only one player deviating from the equilibrium strategy. Each principal of type t only maximizes her utility. The effort of a principal's delegate is denoted by d_s if she is an s-player or d_t if she is a t player. $\hat{d}_t$ or $\hat{\alpha}_t$ indicate that we examine a representative principal of type t.

6.1.1 No-win-no-pay contracts

If all players use no-win-no-pay contracts, then the utility function of an arbitrary principal of type t is

$$\begin{aligned} u_{Pt} &= \frac{\hat{d}_t}{d_s+(n-2)d_t+\hat{d}_t}(1-\hat{\alpha}_t) - \frac{1}{(N-1)}\frac{d_s}{d_s+(n-2)d_t+\hat{d}_t}(1-\alpha_s)V \\ &- \frac{(n-2)}{(N-1)}\frac{d_t}{d_s+(n-2)d_t+\hat{d}_t}(1-\alpha_t)V. \end{aligned}$$

A principal of type s maximizes

$$u_{Ps} = \frac{d_s}{d_s+(n-1)d_t}(1-\alpha_s)V - \frac{(n-1)}{(N-1)}\frac{d_t}{d_s+(n-1)d_t}(1-\alpha_t)V.$$

Notice that a delegate of a principal of type s is concerned with maximizing

$$\pi_{Ds} = \frac{d_s}{d_s+(n-1)d_t}(1-\alpha_s)V - d_s.$$

While an agent of a t typed principal maximizes

$$\pi_{Dt} = \frac{\hat{d}_t}{d_s+(n-2)d_s+\hat{d}_t}(1-\hat{\alpha}_t)V - \hat{d}_t.$$

Using the first order conditions to compute the winning probabilities, we obtain

$$\begin{aligned} p_s &= \frac{(n-1)\alpha_s-(n-2)\alpha_t}{\alpha_t+(n-1)\alpha_s}, \\ p_t &= \frac{\alpha_t}{\alpha_t+(n-1)\alpha_s}. \end{aligned}$$

The problem of player s becomes

$$\pi_{Ps} = \frac{(n-1)\alpha_s-(n-2)\alpha_t-(n-1)\alpha_s^2+(n-2)\alpha_s\alpha_t}{\alpha_t+(n-1)\alpha_s}V - \frac{(n-1)}{(N-1)}\frac{\alpha_t-\alpha_t^2}{\alpha_t+(n-1)\alpha_s}V$$

Looking for a symmetric equilibrium, we can insert $\alpha_s = \alpha_t = \alpha$ into the first order condition. The optimal α is then given by

$$\alpha = \frac{(n-1)^2 N}{N(n^2-n+1)-n}.$$

Hence we obtain, each principal has an utility of

$$u_P = \frac{n(N-n)}{nN(n^2-n+1)-n^2}V$$

and an absolute payoff of

$$\pi_P = \frac{n(N-1)}{nN(n^2-n+1)-n}V.$$

A delegate of any player in the contest will receive

$$\pi_D = \frac{(n-1)^2 N}{N(n^2-n+1)-n}\frac{V}{n} - \frac{(n-1)^3}{n^2}\frac{N}{N(n^2-n+1)-n}V.$$

It is straightforward to show that this is positive. Therefore it is ensured that the participation constraint of the agent is met.

6.1.2 Relative contracts

An agent is paid according to her success relative to the mean of all other agents, that is a delegate of player s maximizes

$$\pi_{Ds} = \beta_s \left(\frac{d_s - d_t}{d_s + (n-1)d_t} \right) V + F_s - d_s.$$

A delegate of a player of type t maximizes

$$\pi_{Dt} = \hat{\beta}_t \left(\frac{\hat{d}_t}{d_s + (n-2)d_t + \hat{d}_t} - \frac{d_s + (n-2)d_t}{(n-1)(d_s + (n-2)d_t + \hat{d}_t)} \right) V + F_t - \hat{d}_t.$$

By deriving the first order conditions and setting them equal, we get the following relationship between the efforts of players of both types

$$d_s = \frac{d_t}{\beta_t}(n-1)\beta_s - (n-2)\beta_t.$$

This yields the winning probabilities

$$\begin{aligned} p_s &= \frac{(n-1)\beta_s - (n-2)\beta_t}{(n-1)\beta_s + \beta_t}, \\ p_t &= \frac{\beta_t}{(n-1)\beta_s + \beta_t}. \end{aligned}$$

Principal s than maximizes

$$\begin{aligned} \pi_{Ps} &= \frac{(n-1)\beta_s - (n-2)\beta_t}{(n-1)\beta_s + \beta_t} - \beta_s \left(\frac{(n-1)\beta_s - (n-2)\beta_t}{(n-1)\beta_s + \beta_t} - \frac{\beta_t}{(n-1)\beta_s + \beta_t} \right) V - F_s \\ &- \frac{(n-1)}{(N-1)} \frac{\beta_t}{(n-1)\beta_s + \beta_t} \\ &+ \frac{(n-1)}{(N-1)} \beta_t \left(\frac{\beta_t}{(n-1)\beta_s + \beta_t} - \frac{(n-1)\beta_s - (n-2)\beta_t + (n-2)\beta_t}{(n-1)((n-1)\beta_s + \beta_t)} \right) V + \frac{(n-1)}{(N-1)} F_t \end{aligned}$$

By deriving the first order condition and inserting $\beta_s = \beta_t = \beta$ we get the utility of any principal

$$u_P = \frac{N-n}{n^2(N-1)} V.$$

But her material payoff is given by

$$\pi_P = \frac{V}{n^2}.$$

As stated above this is the same result as if independent payoff maximizing players would play the contest without delegation.

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