

Equilibrium Contingent Compensation in Contests with Delegation

by

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Southern Economic Journal, April 2007, 73(4), pp. 986-1002.

Abstract

We consider two-player contests in which each player hires a delegate who expends his effort to win a prize on the player's behalf. Endogenizing delegation contracts, we focus on the equilibrium contracts between the players and their delegates. We first show that each player's equilibrium contract is a no-win-no-pay contract. Then, we examine the delegates' equilibrium compensation spreads, effort levels, probabilities of winning, expected payoffs, and the players' equilibrium expected payoffs. We show that economic rents for the delegates may exist.

Keywords: Contest; Delegation; Contingent compensation; Contingent fee; Economic rent; Contract

JEL classification: D72

*I am grateful to Yoram Barzel, Rob Gilles, Hans Haller, Seong Hoon Jeon, Amoz Kats, Fahad Khalil, Chuck Mason, Steve Millsaps, Tim Perri, Djavad Salehi-Isfahani, Jay Shogren, Karl Wärneryd, Kwan Koo Yun, two anonymous referees, and seminar participants at Appalachian State University, University of Washington, University of Wyoming, and Virginia Polytechnic Institute and State University for their helpful comments and suggestions. Earlier versions of this paper were presented at the 2003 Annual Meetings of the Allied Social Science Associations, Washington, D.C., January 2003; and the 2003 Annual Conference of the Korean Econometric Society, Seoul, Korea, February 2003. Part of this research was conducted while I was a Visiting Professor at Virginia Polytechnic Institute and State University. This work was supported by 63 Research Fund, Sungkyunkwan University, 2001.

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1. Introduction

Consider a lawsuit between a plaintiff and a defendant. Each litigant first hires an attorney and writes a contract with him. Then, each attorney expends his effort to win the lawsuit on behalf of his client. Because the outcome of the lawsuit depends on the attorney's effort, which in turn depends on the contract, the litigant must take into account the strategic aspects of contracts when designing her contract.

The purpose of this paper is to consider contests with delegation, like the illustrative example above, focusing on the equilibrium contracts.^{1,2} Specifically, we consider contests in which two players each want to win a prize, and each player hires a delegate who expends his effort to win the prize on the player's behalf. We endogenize delegation contracts between the players and their delegates while explicitly taking into account the delegates' participation constraints based on their reservation wages.

Contests with delegation abound. Examples include litigation in which litigants hire lawyers to win lawsuits; rent-seeking contests in which firms, organizations, or individuals hire lobbyists to acquire government favors and business; and research and development contests in which firms hire research groups or university professors to obtain patents.

We consider two-player contests with bilateral delegation. The players are risk-neutral, and player 1 values the prize more highly than player 2. The players design and provide compensation schemes for their delegates. The delegates are risk-neutral. They have the same nonnegative reservation wage, and have equal ability for the contest. The delegates' effort is not verifiable to a third party, which implies that contracts contingent on the delegates' effort are precluded. We assume that each delegate's compensation is contingent on the outcome of the contest – it depends on whether he wins or loses the prize.

We formally consider the following two-stage game. In the first stage, each player hires a delegate and writes a contract with him. The contract specifies how much the delegate will be paid if he wins the prize and how much if he loses it. Then the players simultaneously announce the contracts written independently. In the second stage, after knowing both contracts, the

delegates choose their effort levels simultaneously and independently. At the end of the second stage, the winner is determined and each player pays compensation to her delegate according to the contract written in the first stage.

Fershtman and Kalai (1997) distinguish between two types of delegation: incentive delegation and instructive delegation. In the case of incentive delegation, a player provides an incentive scheme for her delegate, and the delegate chooses an effort level that maximizes his own payoff, given the incentive scheme. In the case of instructive delegation, a player designs a set of instructions and requires her delegate to follow the instructions. According to this classification, then, this paper adopts incentive delegation. The players in this paper provide compensation schemes for their delegates that are based on the observables, and the delegates choose their effort levels given the compensation schemes.

Solving for the subgame-perfect equilibrium of the two-stage game, we obtain the equilibrium contracts between the players and their delegates, and show that each player's equilibrium contract is a no-win-no-pay contract – a contract that specifies zero compensation for a delegate if he loses the prize. Then, we examine the delegates' equilibrium compensation spreads, effort levels, probabilities of winning, expected payoffs, and the players' equilibrium expected payoffs. We define a delegate's *compensation spread* as the difference between what he earns if he wins the prize and what he earns if he loses it.

We obtain the result of no-win-no-pay contracts because of the constraint that a delegate's compensation should not be negative if he loses the prize, and the assumption that the delegates are risk-neutral. The result of no-win-no-pay contracts makes intuitive sense. By choosing such a contract, each player makes her delegate's compensation spread as wide as possible so that she can most strongly motivate her delegate to win the prize.

Another interesting result is that when a delegate's participation constraint is not binding in equilibrium, his equilibrium expected payoff is greater than his reservation wage. Recall that *economic rent* is defined as that part of the compensation received by the owner of a resource that exceeds the resource's opportunity cost. Then we may say that the gap between the

delegate's equilibrium expected payoff and his reservation wage constitutes the economic rent for the delegate. This economic rent is not created because of restrictions on entry into the "delegate industry," but created because of both the inability to write contracts based on a delegate's effort and the players' strategic decisions on their delegates' compensation. Indeed, competition among potential delegates to become this particular delegate, if any, cannot reduce the delegate's equilibrium expected payoff to his reservation wage.

We also obtain: (i) delegate 1's compensation spread is greater than delegate 2's, and (ii) the equilibrium expected payoff for delegate 1 is greater than that for delegate 2. These occur unless both delegates' participation constraints are binding in the subgame-perfect equilibrium. Part (i) implies that the player with a higher valuation – the hungrier player – offers her delegate better contingent compensation than her opponent does. Part (ii) is very interesting because the delegates are identical before signing up for their players: They have equal ability for the contest, and have the same reservation wage. The difference in the delegates' expected payoffs arises because of the inability to write contracts based on the delegates' effort and because player 1 motivates her delegate more strongly than player 2 – that is, delegate 1's compensation spread is greater than delegate 2's. In this case, even though there exists competition among potential delegates to be employed by player 1, it cannot lead to the same expected payoff for the delegates.

The assumption that the delegates' effort is not verifiable to a third party – which implies the inability to write contracts based on the delegates' effort – is crucial in obtaining the result that the economic rents for the delegates exist. Indeed, the economic rent for each delegate exists because the delegate's effort is his private information. In this respect, the economic rent for each delegate can be interpreted as an informational rent, which is a well-known concept in the principal-agent literature.³

There are two main motives of delegation. The first is that a player wants to use superior ability by hiring a delegate who has more ability than herself; the second is that a player wants to achieve strategic commitments through delegation. Baik and Kim (1997) first introduced

delegation into the literature on the theory of contests. They present a model that involves both motives of delegation. Considering two-player contests in which each player has the option of hiring a delegate, they first establish that buying superior ability is an important motive of delegation. They then show that, as compared to the model without delegation, a total effort level is less when unilateral delegation by the player with a higher valuation or bilateral delegation arises, but it is greater when unilateral delegation by the player with a lower valuation arises. However, they assume that the delegation contracts are exogenously given, and assume implicitly that each delegate's reservation wage is zero. Wärneryd (2000) considers two-player contests with bilateral delegation. He shows that compulsory delegation with moral hazard – that is, where the delegates' effort is unobservable – may be beneficial to the players. He also shows that this result holds even when secret renegotiation opportunities are given to the players and delegates. Schoonbeek (2002) considers a two-player contest in which only one player, say player 1, has the option of hiring a delegate. He compares the equilibrium expected utility of player 1 in the unilateral-delegation case with that in the no-delegation case, focusing on the impact of the risk aversion of player 1 with respect to her money income. Konrad et al. (2004) consider a first-price all-pay auction with two buyers in which each buyer has the option of hiring an agent. They show that in equilibrium each buyer delegates the bidding to her agent, and both buyers are better off. They also show that the buyers provide their agents with incentives to make bids that differ from the bids the buyers would like to make, and the delegation contracts are asymmetric even if the buyers and the auction are perfectly symmetric.

The paper proceeds as follows. In Section 2, we develop the model and set up the two-stage game. We then obtain a unique Nash equilibrium of a second-stage subgame. In Section 3, we analyze the first stage of the two-stage game. We first show that each player writes a no-win-no-pay contract with her delegate. Then we obtain the equilibrium contracts chosen by the players. Section 4 examines the delegates' equilibrium compensation spreads, effort levels, probabilities of winning, their equilibrium expected payoffs, and the players' equilibrium expected payoffs. Finally, Section 5 offers our conclusions.

2. The model

Consider a contest in which two risk-neutral players, 1 and 2, each want to win a single indivisible prize, and each player hires a delegate who expends his effort to win the prize on the player's behalf. Each delegate's effort may be observable to his employer, but is not verifiable to a third party. This implies that contracts contingent on a delegate's effort are precluded. The players' valuations for the prize differ. Let v_i represent player i 's valuation for the prize. We assume that player 1 values the prize more highly than player 2: $v_1 > v_2$. Each player's valuation for the prize is positive and publicly known.

The players design compensation schemes for their delegates: Player i sets compensation for her delegate, denoted by W_i and L_i . Compensation of W_i is paid to delegate i if he wins the prize, and L_i if he loses it. Note that delegate i 's compensation is *contingent* on the outcome of the contest. Let $W_i = \alpha_i v_i$ and let $L_i = \beta_i v_i$, where $\beta_i < \alpha_i < 1$ and $\beta_i \geq 0$.⁴ Then, since v_i is exogenously given, player i designs the compensation scheme for her delegate by choosing the value of α_i and that of β_i .

The delegates are risk-neutral. Delegate i has a reservation wage of R_i , where R_i is nonnegative and is much less than v_i .⁵ This implies that when delegate i signs up for player i , his expected payoff must be greater than or equal to his reservation wage, given the compensation scheme designed by player i . Otherwise – if his expected payoff falls short of his reservation wage – delegate i prefers not to work for player i and accepts alternative employment instead.

We formally consider the following two-stage game. In the first stage, each player hires a delegate and writes a contract with him – in other words, player i designs and offers delegate i a compensation scheme, which delegate i accepts. The contract specifies how much the delegate will be paid if he wins the prize and how much if he loses it. Then the players simultaneously announce the contracts written independently – that is, player 1 announces publicly the values of α_1 and β_1 , and player 2 announces publicly the values of α_2 and β_2 . In the second stage, after knowing both contracts, the delegates choose their effort levels simultaneously and

independently. At the end of the second stage, the winner is determined and each player pays compensation to her delegate according to the contract written in the first stage.

In the second stage of the game, the delegates compete with each other by expending irreversible effort to win the prize. Let x_i represent the effort level expended by delegate i . Effort levels are nonnegative and are measured in units commensurate with the prize. Let $p_1(x_1, x_2)$ denote the probability that delegate 1 wins the prize when the delegates' effort levels are x_1 and x_2 . The contest success function for delegate 1 is given by:⁶

$$p_1(x_1, x_2) = \begin{cases} x_1/(x_1 + x_2) & \text{for } x_1 + x_2 > 0 \\ 1/2 & \text{for } x_1 = x_2 = 0. \end{cases} \quad (1)$$

Let π_i represent the expected payoff for delegate i . Then the payoff function for delegate 1 is

$$\pi_1 = \beta_1 v_1 + (\alpha_1 - \beta_1) v_1 p_1(x_1, x_2) - x_1. \quad (2)$$

Similarly, the payoff function for delegate 2 is

$$\pi_2 = \alpha_2 v_2 - (\alpha_2 - \beta_2) v_2 p_1(x_1, x_2) - x_2. \quad (3)$$

Next, consider the players' expected payoffs computed in the first stage of the game – when player i believes that delegate 1 will expend an effort level of x_1 and delegate 2 will expend an effort level of x_2 in the second stage. Given player i 's contract, (W_i, L_i) , if her delegate wins the prize in the second stage, player i 's net payoff will be $v_i - W_i$; otherwise, player i will gain nothing, but should pay L_i to her delegate. Let G_i represent the expected payoff for player i . Then the payoff function for player 1 is

$$G_1 = -\beta_1 v_1 + (1 - \alpha_1 + \beta_1) v_1 p_1(x_1, x_2). \quad (4)$$

Similarly, the payoff function for player 2 is

$$G_2 = (1 - \alpha_2) v_2 - (1 - \alpha_2 + \beta_2) v_2 p_1(x_1, x_2). \quad (5)$$

Finally, we assume that all of the above is common knowledge among the players and delegates. We employ subgame-perfect equilibrium as the solution concept.

To solve for a subgame-perfect equilibrium of the game, we work backward. We begin by considering the second stage in which, after knowing the contracts chosen in the first stage, (α_1, β_1) and (α_2, β_2) , delegate i seeks to maximize his expected payoff over his effort level, given the other delegate's effort level. Given a positive effort level of delegate 2, the first-order condition for maximizing delegate 1's expected payoff, π_1 , yields

$$(\alpha_1 - \beta_1)v_1(\partial p_1(x_1, x_2)/\partial x_1) = 1. \quad (6)$$

Given a positive effort level of delegate 1, the first-order condition for maximizing delegate 2's expected payoff, π_2 , yields

$$-(\alpha_2 - \beta_2)v_2(\partial p_1(x_1, x_2)/\partial x_2) = 1. \quad (7)$$

Conditions (6) and (7) say that, given the other delegate's positive effort level, if delegate i 's best response – an effort level that maximizes his expected payoff – is positive, then his marginal gross payoff – the left-hand side of condition (6) or (7) – must be equal to his marginal cost, 1, at that effort level.⁷ Delegate i 's payoff function is strictly concave in his effort level. Thus the second-order condition for maximizing π_i is satisfied, and delegate i 's best response is unique.

A Nash equilibrium of the second-stage subgame is a pair of effort levels, one for each delegate, at which each delegate's effort level is the best response to his opponent's. Thus it satisfies the delegates' reaction functions – which are derived from conditions (6) and (7) – simultaneously. We obtain a unique Nash equilibrium:

$$x_1^N = (\alpha_1 - \beta_1)^2 v_1^2 (\alpha_2 - \beta_2) v_2 / \{(\alpha_1 - \beta_1) v_1 + (\alpha_2 - \beta_2) v_2\}^2$$

and

$$x_2^N = (\alpha_1 - \beta_1) v_1 (\alpha_2 - \beta_2)^2 v_2^2 / \{(\alpha_1 - \beta_1) v_1 + (\alpha_2 - \beta_2) v_2\}^2. \quad (8)$$

Using expression (8), we obtain $x_1^N/x_2^N = (\alpha_1 - \beta_1)v_1/(\alpha_2 - \beta_2)v_2$ or, equivalently, $x_1^N/(\alpha_1 - \beta_1)v_1 = x_2^N/(\alpha_2 - \beta_2)v_2$.⁸ Note that $(\alpha_i - \beta_i)v_i$ is the difference between what delegate i earns if he wins the prize and what he earns if he loses it. Let us call it delegate i 's *compensation spread*.⁹ Then the first expression says that, at the Nash equilibrium, the ratio of the delegates' effort levels is equal to the ratio of their compensation spreads. We can explain this result as follows: Since each delegate's probability of winning is a function of the ratio of the two delegates' effort levels, the equilibrium effort ratio should be equal to the compensation-spread ratio in order to satisfy the mutual-best-responses property of Nash equilibrium. In the second expression, $x_i^N/(\alpha_i - \beta_i)v_i$ is the proportion of delegate i 's equilibrium effort level – which is "dissipated" in pursuit of the prize – to his compensation spread. The second expression says that these proportions are the same between the delegates. It follows immediately from expression (8) that the proportion is less than a quarter.

3. Equilibrium contingent compensation

In this section, we analyze the first stage of the two-stage game. We first show that each player writes a *no-win-no-pay contract* with her delegate – that is, player i chooses a contract with $\beta_i = 0$. Then we obtain the equilibrium contracts – also called the equilibrium contingent compensation – chosen by the players.

In the first stage, the players choose their contracts simultaneously and independently. The players have perfect foresight about the second-stage competition – more specifically, the Nash equilibrium of each second-stage subgame. Let $p_1(x_1^N, x_2^N)$ be the probability that delegate 1 wins the prize at the Nash equilibrium of the second-stage subgame, given contracts, (α_1, β_1) and (α_2, β_2) . Then, using payoff functions (4) and (5), we obtain the players' payoff functions that take into account the Nash equilibrium of the second-stage subgame:

$$G_1^N = -\beta_1 v_1 + (1 - \alpha_1 + \beta_1)v_1 p_1(x_1^N, x_2^N)$$

and

$$G_2^N = (1 - \alpha_2)v_2 - (1 - \alpha_2 + \beta_2)v_2 p_1(x_1^N, x_2^N),$$

where $p_1(x_1^N, x_2^N) = (\alpha_1 - \beta_1)v_1 / \{(\alpha_1 - \beta_1)v_1 + (\alpha_2 - \beta_2)v_2\}$, which are obtained using function (1) and expression (8).

When choosing a contract for her delegate, each player should consider her delegate's participation constraint. Having perfect foresight about the Nash equilibrium of each second-stage subgame, the players and delegates can compute, in the first stage, the delegates' expected payoffs. Using payoff functions (2) and (3), we obtain the delegates' payoff functions that are associated with the Nash equilibrium of the second-stage subgame, given contracts, (α_1, β_1) and (α_2, β_2) :

$$\pi_1^N = \beta_1 v_1 + (\alpha_1 - \beta_1)v_1 p_1(x_1^N, x_2^N) - x_1^N$$

and

$$\pi_2^N = \alpha_2 v_2 - (\alpha_2 - \beta_2)v_2 p_1(x_1^N, x_2^N) - x_2^N.$$

Delegate i 's participation constraint is then $\pi_i^N \geq R_i$.

Now player i faces the following constrained-maximization problem:

$$\begin{aligned} & \text{Max}_{\alpha_i, \beta_i} G_i^N \\ & \text{subject to } \pi_i^N \geq R_i. \end{aligned}$$

That is, taking the opponent's contract as given, player i seeks to maximize her expected payoff over her contract, (α_i, β_i) , subject to delegate i 's participation constraint. By doing so, she obtains her best response – denoted by (α_i^b, β_i^b) – to the given contract of her opponent. To solve for each player's best response in an "informative" way, we will break up the constrained-maximization problem into two pieces. First, we will look at the problem of how to maximize each player's expected payoff without considering her delegate's participation constraint. Then, we will look at the problem of how to choose each player's best response while considering her delegate's participation constraint.

We begin by looking at the first step – maximizing each player's expected payoff without considering her delegate's participation constraint. We obtain Lemma 1.¹⁰

Lemma 1. (a) Given player j 's contract, (α_j, β_j) , and given α_i , player i 's expected payoff is always decreasing in β_i : In terms of the symbols, we have $\partial G_i^N / \partial \beta_i < 0$.¹¹ (b) Given player j 's contract, (α_j, β_j) , and given β_i , player i 's expected payoff is maximized at $\alpha_i = \beta_i + k_i$, where $k_i = [- (\alpha_j - \beta_j)v_j + \{(\alpha_j - \beta_j)^2 v_j^2 + (\alpha_j - \beta_j)v_i v_j\}^{1/2}] / v_i$.

Part (a) can be explained as follows. As β_i decreases, delegate i 's compensation spread increases. A larger compensation spread in turn gives delegate i more incentives to win the prize and makes him exert more effort.¹² A higher effort level of delegate i then yields a higher probability that delegate i wins the prize in second-stage equilibrium. Therefore, a higher probability of winning and less compensation in the case of losing lead to an increase in player i 's expected payoff.

In the $\beta_i \alpha_i$ -space of Figures 1 and 2, the graph of $\alpha_i = \beta_i + k_i$ is a straight line with a vertical intercept of k_i and a slope of unity. It is easy to see that k_i is positive but less than a half. It follows from Lemma 1 that, given player j 's contract, (α_j, β_j) , player i 's expected payoff is maximized when $(\alpha_i, \beta_i) = (k_i, 0)$.

Next, we look at the second step – the problem of how to choose each player's best response while considering her delegate's participation constraint. Consider first delegate i 's participation constraint whose weak-inequality sign is replaced by the equals sign – that is, consider $\pi_i^N = R_i$. Figures 1 and 2 illustrate its graph. Let us call it delegate i 's participation constraint curve. It is straightforward to see that, in the $\beta_i \alpha_i$ -space, delegate i 's participation constraint curve slopes downward from left to right, and has a vertical intercept of m_i , where m_i satisfies

$$m_i^3 v_i^3 = R_i \{m_i v_i + (\alpha_j - \beta_j) v_j\}^2. \quad (9)$$

Player i 's contracts that satisfy her delegate's participation constraint, $\pi_i^N \geq R_i$, lie on or above her delegate's participation constraint curve. Thus they are located in the shaded areas of Figures 1 and 2. Given player j 's contract, (α_j, β_j) , because m_i increases in R_i while k_i is independent of R_i , we have two different cases depending on the size of delegate i 's reservation wage, R_i . Figure 1 shows the first case where delegate i 's participation constraint is not binding: $k_i > m_i$. This case occurs when R_i is "low." Figure 2 shows the second case where delegate i 's participation constraint is binding: $k_i \leq m_i$. This case occurs when R_i is "high."

Given player j 's contract, (α_j, β_j) , player i 's best response to (α_j, β_j) is defined as a contract that maximizes her expected payoff, G_i^N , subject to delegate i 's participation constraint, $\pi_i^N \geq R_i$. Denote it by (α_i^b, β_i^b) . Using Lemma 1, we obtain Lemma 2.

Lemma 2. (a) *In the case where R_i is low, delegate i 's participation constraint is not binding, and player i 's best response to player j 's contract, (α_j, β_j) , is $(k_i, 0)$: In terms of the symbols, we have $k_i > m_i$ and $(\alpha_i^b, \beta_i^b) = (k_i, 0)$ when R_i is low. (b) *In the case where R_i is high, delegate i 's participation constraint is binding, and player i 's best response is $(m_i, 0)$: In terms of the symbols, we have $k_i \leq m_i$ and $(\alpha_i^b, \beta_i^b) = (m_i, 0)$ when R_i is high.**

Part (a) says that, when delegate i 's reservation wage is low, player i chooses a contract that gives delegate i an expected payoff higher than his reservation wage. The explanation for this follows. Delegate i will compete against delegate j to win the prize in the second stage. Player i wants to induce delegate i to exert the "optimal" effort – the optimal effort for player i – by choosing the "best" contract, given player j 's contract, (α_j, β_j) . In this case, the "best" contract – that maximizes player i 's expected payoff when her delegate's participation constraint is absent – happens to yield delegate i 's expected payoff greater than his reservation wage, because his reservation wage is low. While player i looks benevolent, she is actually pursuing her self-interest.

In the case where delegate i 's reservation wage is high, the "best" contract – the solution to the unconstrained-maximization problem – yields delegate i 's expected payoff less than his reservation wage. Hence, to take care of her delegate's participation constraint, player i chooses a contract that lies on delegate i 's participation constraint curve.

Now, we obtain the equilibrium contracts chosen by the players. Let (α_i^*, β_i^*) represent player i 's contract that is specified in the subgame-perfect equilibrium of the two-stage game. We first obtain from Lemma 2 that $\beta_1^* = \beta_2^* = 0$. In order to obtain α_1^* and α_2^* , we utilize the players' reaction curves in the $\alpha_1\alpha_2$ -space. It follows immediately from Lemma 2 that, given $\beta_j^* = 0$, player i 's reaction curve in the $\alpha_1\alpha_2$ -space is the graph of $\alpha_i^b = \max\{k_i^o, m_i^o\}$, where $k_i^o = \{-\alpha_j v_j + (\alpha_j^2 v_j^2 + \alpha_j v_i v_j)^{1/2}\}/v_i$ and m_i^o satisfies $(m_i^o v_i)^3 = R_i(m_i^o v_i + \alpha_j v_j)^2$, which are based on Lemma 1 and equation (9), respectively. Then, the intersection of the two reaction curves determines α_1^* and α_2^* . Because m_i^o depends on – more specifically, increases in – delegate i 's reservation wage, R_i , the equilibrium contracts of the players depend on the delegates' reservation wages. Henceforth, to get more mileage, we assume that the delegates have the same reservation wage: $R_1 = R_2 = R$.

Figure 3 is useful in obtaining α_1^* and α_2^* . For concise exposition, we draw the graphs of k_i^o and m_i^o separately rather than draw the graph of $\alpha_i^b = \max\{k_i^o, m_i^o\}$, which is player i 's reaction curve. Lemma A1 in the Appendix describes properties of the graphs in Figure 3. Lemma 3 describes the equilibrium contracts of the players, (α_1^*, β_1^*) and (α_2^*, β_2^*) .

Lemma 3. (a) *If the intersection of the graphs of m_1^o and m_2^o lies on line segment OA, or equivalently, if $0 \leq R < R^A$, then (α_1^*, α_2^*) occurs at point Q – the intersection of the graphs of k_1^o and k_2^o .* (b) *If the intersection of the graphs of m_1^o and m_2^o lies on line segment AD, or equivalently, if $R^A \leq R < R^D$, then (α_1^*, α_2^*) occurs at the intersection, on arc QD, of the graphs of k_1^o and m_2^o .* (c) *If the intersection of the graphs of m_1^o and m_2^o lies on line segment DS, or equivalently, if $R^D \leq R < v_2/4$, then (α_1^*, α_2^*) occurs at this very intersection: $(\alpha_1^*, \alpha_2^*) = (4R/v_1, 4R/v_2)$.¹³* (d) *We obtain $\beta_1^* = \beta_2^* = 0$, regardless of the value of R , where $0 \leq R < v_2/4$.*

Lemma 3 says that the equilibrium contracts of the players are no-win-no-pay contracts. More specifically, the equilibrium contract of player i specifies that delegate i earns $W_i^* = \alpha_i^* v_i$ if he wins the prize, and $L_i^* = \beta_i^* v_i = 0$ if he loses it.¹⁴ This means that delegate i 's compensation spread in the subgame-perfect equilibrium is $\alpha_i^* v_i$. Why does each player choose a no-win-no-pay contract? A convincing reason is that, by doing so, each player can most strongly motivate her delegate to win the prize. Indeed, by choosing such a contract, each player makes her delegate's compensation spread – the gap between what her delegate earns if he wins the prize and what he earns if he loses it – as wide as possible. Then, facing such a contract, delegate i tries his best to win the prize in the second stage, which is beneficial to player i .

Lemma 3 implies that, as the delegates' reservation wage increases beyond R^A , the delegates' equilibrium compensation spreads – or their equilibrium contingent fees – increase. This can be explained as follows. First, when the reservation wage increases, the players must offer their delegates higher compensation spreads in order to hire them. Second, when the opponent offers a higher compensation spread to her delegate, each player has an incentive to follow suit. Facing a more aggressive delegate of the opponent, each player must make her delegate more aggressive by increasing his compensation spread.

Lemma 3 establishes that there are three possible types of equilibrium-contracts pairs: the pairs of contracts at which neither of the delegates' participation constraints is binding; the pairs of contracts at which delegate 2's participation constraint is binding, but delegate 1's is not; and the pairs of contracts at which both delegates' participation constraints are binding. The first type, called type I, is associated with part (a) of Lemma 3; the second type, called type II, is associated with part (b); and the third type, called type III, is associated with part (c).

4. Three types of equilibrium-contracts pairs

In this section, we closely look at the three types of equilibrium-contracts pairs, and examine the delegates' compensation spreads, their effort levels, their probabilities of winning, their expected payoffs, and the players' expected payoffs.

Let (x_1^*, x_2^*) represent the effort levels of the delegates that are specified in the subgame-perfect equilibrium. Let $p_1(x_1^*, x_2^*)$ be the probability that delegate 1 and thus player 1 win the prize in the subgame-perfect equilibrium. Let π_i^* and G_i^* represent the expected payoff for delegate i and that for player i , respectively, in the subgame-perfect equilibrium. Then, using Lemma 3 and expressions (1) through (5) and (8), we obtain Proposition 1.¹⁵

Proposition 1. *[type I] In the case where the delegates' reservation wages are low, and thus neither of the delegates' participation constraints is binding in equilibrium, we obtain: (a) $\alpha_1^* v_1 > \alpha_2^* v_2$ and $\alpha_1^* < \alpha_2^* < 1/2$, (b) $x_1^* > x_2^*$, (c) $p_1(x_1^*, x_2^*) > 1/2$, (d) $\pi_1^* > \pi_2^* > R$, and (e) $G_1^* > G_2^* > 0$. [type II] In the case where the delegates' reservation wage is rather high, and thus delegate 2's participation constraint is binding but delegate 1's is not in equilibrium, we obtain: (a) $\alpha_1^* v_1 > \alpha_2^* v_2$ and $\alpha_1^* < \alpha_2^*$, (b) $x_1^* > x_2^*$, (c) $p_1(x_1^*, x_2^*) > 1/2$, (d) $\pi_1^* > \pi_2^* = R$, and (e) $G_1^* > G_2^* > 0$. [type III] In the case where the delegates' reservation wage is high, and thus both delegates' participation constraints are binding in equilibrium, we obtain: (a) $\alpha_1^* v_1 = \alpha_2^* v_2$ and $\alpha_1^* < \alpha_2^*$, (b) $x_1^* = x_2^*$, (c) $p_1(x_1^*, x_2^*) = 1/2$, (d) $\pi_1^* = \pi_2^* = R$, and (e) $G_1^* > G_2^* > 0$.*

Proposition 1 is summarized in Table 1. Consider type I of the equilibrium-contracts pairs. First of all, note that the results hold true even though the delegates' reservation wages differ, as far as their participation constraints are not binding in the subgame-perfect equilibrium. Part (a) says that delegate 1's compensation spread is greater than delegate 2's. In other words, the player with a higher valuation – the hungrier player – offers her delegate better contingent compensation than her opponent does. Confronting player 1 – the hungrier player – player 2 tries to overcome her relative "weakness" in the valuations for the prize by choosing α_2^* which is

greater than α_1^* . However, this turns out to be not enough to make her delegate more aggressive than her opponent's. Indeed, delegate 1 exerts more effort than delegate 2, and thus becomes the *favorite* because delegate 1's compensation spread – or his contingent fee – is greater than delegate 2's.¹⁶

Another interesting result is that the equilibrium expected payoff for delegate 1 is greater than that for delegate 2. This result is very interesting because the delegates are identical before signing up for their players: They have the same reservation wage and have equal ability for the contest (see function (1)).¹⁷ The result arises due to the inability to write contracts based on the delegates' effort and because player 1 motivates her delegate more strongly than player 2 – that is, delegate 1's compensation spread is greater than delegate 2's. In this case, even though there exists competition among potential delegates to be employed by player 1, it cannot lead to the same expected payoff for the delegates. Delegate 2 signs up for player 2 because his equilibrium expected payoff is greater than his reservation wage. But he would be luckier if he were selected as delegate 1 by player 1's "random drawing."

Yet another interesting result is that each delegate's equilibrium expected payoff is greater than his reservation wage. The gap between his equilibrium expected payoff and his reservation wage constitutes the *economic rent* for the delegate. This economic rent for each delegate is not created due to restrictions on entry into the "delegate industry," but created due to both the inability to write contracts based on a delegate's effort and the players' strategic decisions on their delegates' compensation.¹⁸

Part (e) says that the equilibrium expected payoff for player 1 is greater than that for player 2. This follows immediately from the assumption that $v_1 > v_2$ and from the results that $\beta_1^* = \beta_2^* = 0$, $\alpha_1^* < \alpha_2^*$, and $p_1(x_1^*, x_2^*) > 1/2$, and makes intuitive sense.

Next, consider type II of the equilibrium-contracts pairs. We obtain the same results as for type I with the exception that delegate 2's equilibrium expected payoff is equal to his reservation wage. For type II of the equilibrium-contracts pairs, given player 1's equilibrium contract, player 2's "best" contract – that maximizes player 2's expected payoff when her

delegate's participation constraint is absent – yields delegate 2's expected payoff less than his reservation wage, because his reservation wage is rather high. Hence, to hire a delegate, player 2 must offer her delegate better contingent compensation that guarantees the delegate his reservation wage. Note that, as the delegates' reservation wage increases, the gap between the delegates' equilibrium expected payoffs narrows. This is because delegate 2's equilibrium expected payoff increases – since his participation constraint is binding – as R increases, while delegate 1's is "independent" of the reservation wage. Since $v_1 > v_2$ – more precisely, $\alpha_1^* v_1 > \alpha_2^* v_2$ – and the delegates have the same reservation wage, delegate 1's participation constraint is not binding. Player 1 still has some breathing space.

Finally, consider type III: the pairs of contracts at which both delegates' participation constraints are binding. Part (a) says that delegate 1's compensation spread is equal to delegate 2's. Since both delegates' participation constraints are binding in this case, the delegates with the same reservation wage must be treated equally in terms of their compensation – that is, their equilibrium expected payoffs must be the same and equal to their common reservation wage. Hence, given $\beta_1^* = \beta_2^* = 0$, we must have $\alpha_1^* v_1 = \alpha_2^* v_2$. Part (a) also says that α_2^* is greater than α_1^* .¹⁹ This follows immediately from $\alpha_1^* v_1 = \alpha_2^* v_2$ and $v_1 > v_2$.

Parts (b), (c), and (d) show that the delegates expend the same effort level, have the same probability of winning, and have the same expected payoff in equilibrium. This is natural because the delegates are motivated equally to win the prize with the same compensation spread.

Part (e) says that the equilibrium expected payoff for player 1 is greater than that for player 2. This follows immediately from the assumption that $v_1 > v_2$ and from the results that $\beta_1^* = \beta_2^* = 0$ and $\alpha_1^* < \alpha_2^*$. The players offer their delegates the same compensation spread, so that the delegates exert the same effort and therefore end up with the even contest – that is, both delegates have the same probability of winning in equilibrium. However, player 1's expected payoff is greater than player 2's because player 1 values the prize more highly than player 2.

5. Conclusions

We have considered contests in which two players each want to win a prize, and each player hires a delegate who expends his effort to win the prize on the player's behalf. After obtaining the equilibrium contracts between the players and their delegates, we have examined the delegates' equilibrium compensation spreads, effort levels, probabilities of winning, expected payoffs, and the players' equilibrium expected payoffs.

First we have shown that each player chooses a no-win-no-pay contract in equilibrium – that is, player i chooses a contract with $\beta_i^* = 0$ – and explained that she does so in order to most strongly motivate her risk-neutral delegate to win the prize.

Then we have found that there are three types of equilibrium-contracts pairs, depending on the size of the delegates' reservation wage: the pairs of contracts at which neither of the delegates' participation constraints is binding, the pairs of contracts at which delegate 2's participation constraint is binding but delegate 1's is not; and the pairs of contracts at which both delegates' participation constraints are binding. For the first two types of equilibrium-contracts pairs, delegate 1's equilibrium compensation spread is greater than delegate 2's; delegate 1's equilibrium effort level is greater than delegate 2's; and delegate 1's equilibrium expected payoff is greater than delegate 2's. For the third type of the equilibrium-contracts pairs, delegate 1's equilibrium compensation spread, effort level, and his equilibrium expected payoff are equal to delegate 2's, respectively. For all the three types of equilibrium-contracts pairs, the equilibrium expected payoff for player 1 is greater than that for player 2.

We have assumed that player 1 values the prize more highly than player 2. In the case where the players value the prize equally, only symmetric types of the equilibrium-contracts pairs occur, depending on the size of the delegates' reservation wage: the pairs of contracts at which both delegates' participation constraints are not binding, and the pairs of contracts at which both delegates' participation constraints are binding. Asymmetric equilibrium-contracts pairs at which one delegate's participation constraint is binding while the other delegate's is not, vanish in this symmetric case. For both types of equilibrium-contracts pairs, the delegates'

equilibrium compensation spreads, effort levels, their equilibrium expected payoffs, and the players' equilibrium expected payoffs are the same.

We have assumed that β_i can take on only nonnegative values. What happens if we set a negative number as the lower bound of β_i ? First of all, the equilibrium contract of each player is no longer a no-win-no-pay contract. Instead, it may specify the lower bound as the equilibrium value of β_i . This means that delegate i is required to pay the absolute value of $\beta_i v_i$ to his employer if he loses the prize. Or, following the fixed-fee interpretation in footnote 4, he is required to pay the amount to his employer, regardless of the outcome of the contest. To put it differently, player i sells delegate i – for the amount – both the right to compete for the prize and the right to share the prize with her when he wins it.²⁰ Second, if the lower bound of β_i is a sufficiently small negative number, there may be no economic rents for the delegates in equilibrium or the gap between the delegates' equilibrium expected payoffs.

We have assumed that the delegates' effort is not verifiable to a third party. If the delegates' effort is observable and verifiable, so that contracts can be written based on their effort, then there may be no economic rents for the delegates in equilibrium or the gap between the delegates' equilibrium expected payoffs. Indeed, this happens when the players adopt the following compensation structure for their delegates: A delegate is paid zero if his effort is below a stipulated effort, and a positive amount if his effort is greater than or equal to the stipulated effort.

We have assumed that the delegates have equal ability for the contest, and have the same reservation wage. By doing so, we have set aside the question of who hires whom. We may be able to endogenize choice of delegate types, by differentiating delegate types by delegates' ability for the contest; by introducing delegate types into contest success functions; and by letting each delegate's reservation wage depend on his type. This alternative model is an interesting, natural extension of the paper, but we may have difficulty in choosing a specific form of the function that describes the relationship between delegate type and reservation wage.

A further extension of this paper is a model that incorporates players' decisions on delegation. Baik and Kim (1997) endogenize players' decisions on delegation. But they assume that the contracts between the players and their delegates are exogenously given, and assume implicitly that each delegate's reservation wage is zero.

Finally, we have assumed that the upper bound of α_i is unity. A model with a lower cap on α_i may yield interesting results.²¹ We leave all these considerations for future research.

Appendix: Properties of the graphs in Figure 3

Lemma A1. (a) k_i^o is increasing in α_j at a decreasing rate. (b) m_i^o is increasing in α_j at a decreasing rate. (c) As the delegates' reservation wage, R , increases, the graph of m_1^o shifts to the right while the graph of m_2^o shifts upward. (d) The intersection of the graphs of m_1^o and m_2^o always occurs on straight line OS , which is the graph of $\alpha_2 = (v_1/v_2)\alpha_1$. (e) Point Q – the intersection of the graphs of k_1^o and k_2^o – lies between straight line OS and the 45° line. (f) The graph of k_2^o cuts straight line OS at point H . If the graph of m_2^o also passes through point H , then, at the point, the slope of the graph of m_2^o is greater than that of the graph of k_2^o .

The proof of Lemma A1 is straightforward and therefore omitted. Lemma A1 says that, as the delegates' reservation wage, R , increases, the intersection of the graphs of m_1^o and m_2^o moves up along straight line OS . However, note that, as the delegates' reservation wage changes, the graphs of k_1^o and k_2^o remain unchanged because k_i^o is independent of the delegates' reservation wage. In Figure 3, the graph of k_1^o cuts straight line OS at point D and the graph of k_2^o cuts straight line OS at point H . It is easy to see that we have $(\alpha_1, \alpha_2) = (1/3, v_1/3v_2)$ at point D and $(\alpha_1, \alpha_2) = (v_2/3v_1, 1/3)$ at point H .

Based on part (f) of Lemma A1, we can draw the graph of m_2^o that passes through both point A – a point on line segment OH – and point Q . Let R^A be the value of R that is associated with this particular graph of m_2^o , denoted by $m_2^o(R^A)$ in Figure 3. Let R^D be the value of R that is associated with the graph of m_2^o passing through point D , denoted by $m_2^o(R^D)$ in Figure 3. We obtain $R^D = v_1/12$. The explicit solution for R^A is unobtainable.

Endnotes

1. A contest is defined as a situation in which players compete with one another by expending irreversible effort to win a prize. Contests have been studied by many economists: Loury (1979), Tullock (1980), Rosen (1986), Dixit (1987), Hillman and Riley (1989), Ellingsen (1991), Nitzan (1991, 1994), Baye et al. (1993), Baik (1994, 2004), Nti (1997), Clark and Riis (1998), Che and Gale (1998), Hurley and Shogren (1998), Konrad (2000), and Szymanski (2003), to name a few.

2. Ever since Schelling (1960) pointed out the benefit of strategic delegation, many economists have studied delegation in different contexts. For example, Vickers (1985), Fershtman and Judd (1987), Sklivas (1987), and Das (1997) have studied strategic managerial delegation; Burtraw (1993) and Segendorff (1998) have studied delegation in bargaining situations; Fershtman et al. (1991), Katz (1991), and Fershtman and Kalai (1997) have studied delegation with observable contracts, delegation with unobservable contracts, and unobserved delegation, respectively; Ray (1999) has studied share tenancy; Baik and Kim (1997), Wärneryd (2000), Schoonbeek (2002), and Konrad et al. (2004) have studied delegation in contests.

3. For an explanation about the concept of informational rent, see Rasmusen (2001).

4. Looking at this compensation structure, one may say that $\beta_i v_i$ represents a fixed fee that is paid to delegate i , regardless of the outcome of the contest, while $(\alpha_i - \beta_i)v_i$ is a contingent fee that is paid to delegate i only if he wins the prize. The compensation structure that comprises a fixed fee and a contingent fee is the standard form of contract between litigants and attorneys in personal injury and medical malpractice litigation in the United States. See, for example, Danzon (1983), Rubinfeld and Scotchmer (1993), and Santore and Viard (2001) for details. The American Bar Association Model Rules of Professional Conduct require that fixed fees in such tort litigation should not be negative (see Santore and Viard, 2001). This justifies the nonnegativity constraint on β_i .

5. However, we will assume in Section 3 that the delegates have the *same* reservation wage. By doing so, we will make our model more tractable and will not address the question of who hires whom. This question is interesting but difficult. We leave it for future research. We will also assume in Section 3 that the delegates' reservation wage is less than $v_2/4$.

6. We use simplest logit-form contest success functions throughout the paper. They are extensively used in the contest literature. See, for example, Tullock (1980), Hillman and Riley (1989), Ellingsen (1991), Nitzan (1991), Hurley and Shogren (1998), Wärneryd (2000), Szymanski (2003), and Stein and Rapoport (2004).

7. Note that, given zero effort of his opponent, each delegate's best response is to expend infinitesimal effort.

8. Any "well-behaved" contest success functions that are homogeneous of degree zero in the delegates' effort levels yield the same result. Note that, given homogeneous-of-degree-zero contest success functions, each delegate's probability of winning depends only on the *ratio* of the two delegates' effort levels.

9. Also, as mentioned in footnote 4, it can be interpreted as a contingent fee that is paid to delegate i only if he wins the prize.

10. To shorten the paper, we omit the proofs of Lemmas 1 and 2. They are available from the author upon request.

11. Throughout the paper, when we use i and j at the same time, we mean that $i \neq j$.

12. Indeed, using expression (8), we can show that, as β_i decreases, the equilibrium effort level of delegate i in the second stage increases: $\partial x_i^N / \partial \beta_i < 0$. We can also show that, as β_i decreases, the probability that delegate i wins the prize in second-stage equilibrium increases: $\partial p_1(x_1^N, x_2^N) / \partial \beta_1 < 0$ and $\partial p_1(x_1^N, x_2^N) / \partial \beta_2 > 0$.

13. We must assume that $R < v_2/4$. Otherwise – that is, if $R \geq v_2/4$ – player 2 ends up with a nonpositive expected payoff, which implies that player 2 has no incentive to hire a delegate at the beginning. This cap on the reservation wage may seem to exclude interesting cases.

However, this is not so because each delegate's expected payoff is defined as his gross expected payoff minus his *effort level*.

14. Following the interpretation of the compensation structure in footnote 4, we can view this equilibrium contingent compensation as follows: Delegate i 's fixed fee – which is paid to him, regardless of the outcome of the contest – is zero, and his contingent fee – which is paid to him only if he wins the prize – is $\alpha_i^* v_i$.

15. To shorten the paper, we omit the proof of Proposition 1. It is available from the author upon request.

16. Dixit (1987) calls the favorite the contestant who has a probability of winning greater than a half at the Nash equilibrium and the underdog the contestant whose probability of winning at the Nash equilibrium is less than a half. Baik (1994, 2004) calls the former the Nash winner and the latter the Nash loser.

17. The result is more interesting when we consider the case where delegate 2's reservation wage is greater than delegate 1's.

18. Santore and Viard (2001) show that the American Bar Association Model Rules of Professional Conduct that require a minimum fixed fee of zero – similar to the nonnegativity constraint on β_i in this paper – can create economic rents for attorneys (see footnote 4). Rasmusen (2001, p. 181) mentions in a standard principal-agent framework that the principal may pick a contract in which she pays the agent more than his reservation wage. Schoonbeek (2002) shows in a two-player contest with *unilateral* delegation that the equilibrium expected utility of the delegate may be greater than his reservation wage. Lawarrée and Shin (2005) show that within a flexible organization, not only an efficient agent but also an inefficient agent may acquire a rent.

19. For type III, (α_1^*, α_2^*) occurs at the intersection of the graphs of m_1^o and m_2^o – which lies on line segment DS in Figure 3. We obtain $(\alpha_1^*, \alpha_2^*) = (4R/v_1, 4R/v_2)$.

20. This interpretation makes sense if the prize is a pecuniary one, but it may not make sense if the prize is, for example, winning a criminal trial.

21. A lower cap on α_i can be justified by the fact that many states in the United States have limits on contingent fees for tort cases. See, for example, Danzon (1983), Rubinfeld and Scotchmer (1993), and Emons (2000).

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TABLE 1
Three Types of Equilibrium-Contracts Pairs

	Type I	Type II	Type III
Reservation Wage	$0 \leq R < R^A$	$R^A \leq R < R^D$	$R^D \leq R < v_2/4$
Contracts	$\alpha_1^* < \alpha_2^* < 1/2$ $\beta_1^* = \beta_2^* = 0$	$\alpha_1^* < \alpha_2^*$ $\beta_1^* = \beta_2^* = 0$	$\alpha_1^* < \alpha_2^*$ $\beta_1^* = \beta_2^* = 0$
Compensation Spreads	$\alpha_1^* v_1 > \alpha_2^* v_2$	$\alpha_1^* v_1 > \alpha_2^* v_2$	$\alpha_1^* v_1 = \alpha_2^* v_2$
Delegates' Effort Levels	$x_1^* > x_2^*$	$x_1^* > x_2^*$	$x_1^* = x_2^*$
Probability of Winning	$p_1(x_1^*, x_2^*) > 1/2$	$p_1(x_1^*, x_2^*) > 1/2$	$p_1(x_1^*, x_2^*) = 1/2$
Expected Payoffs for the Delegates	$\pi_1^* > \pi_2^* > R$	$\pi_1^* > \pi_2^* = R$	$\pi_1^* = \pi_2^* = R$
Expected Payoffs for the Players	$G_1^* > G_2^* > 0$	$G_1^* > G_2^* > 0$	$G_1^* > G_2^* > 0$

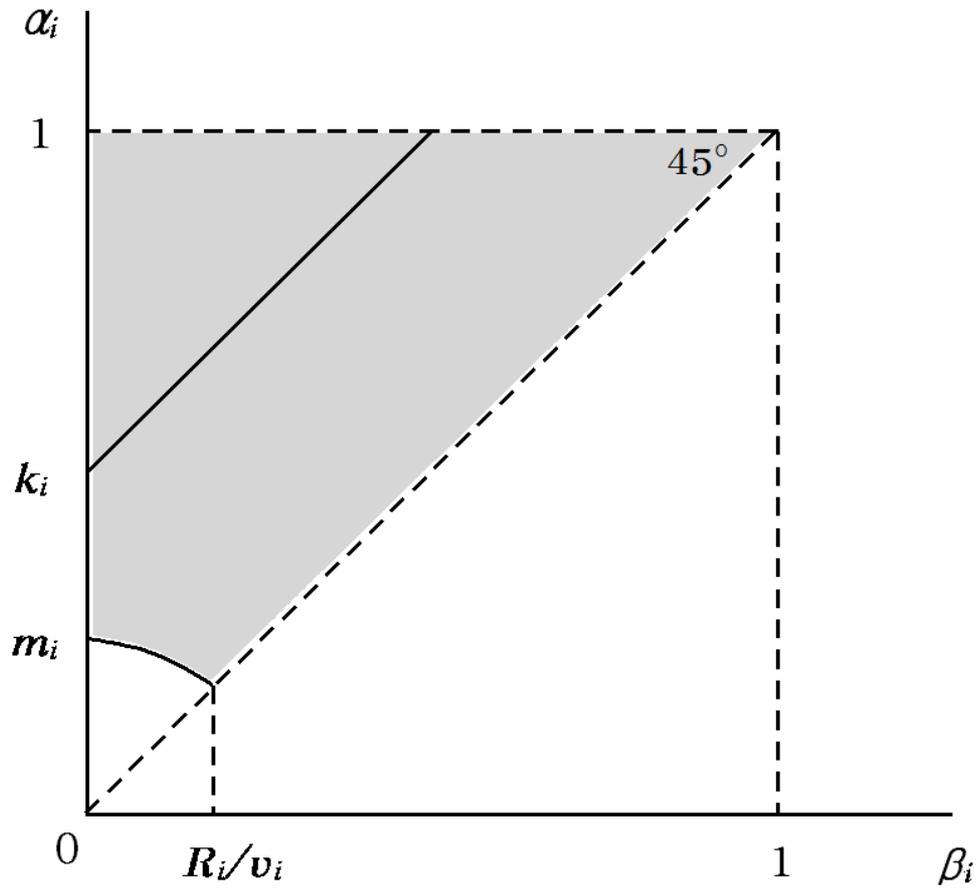


Figure 1. Nonbinding participation constraint.

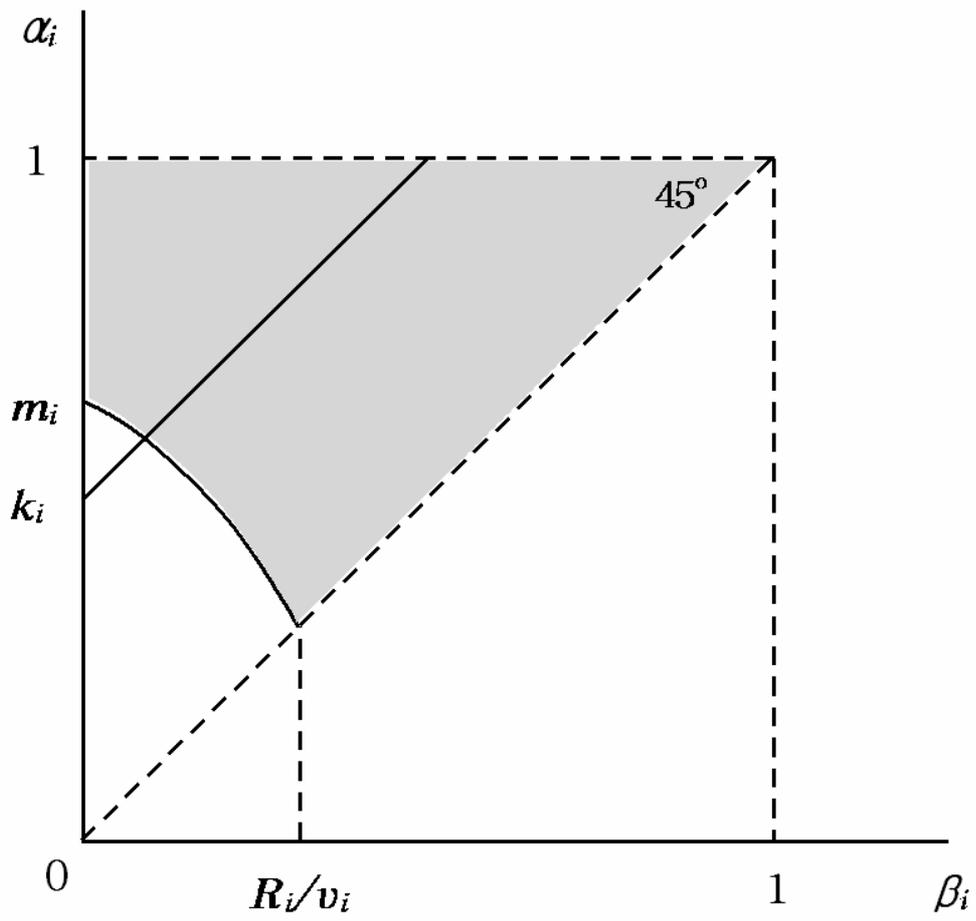


Figure 2. Binding participation constraint.

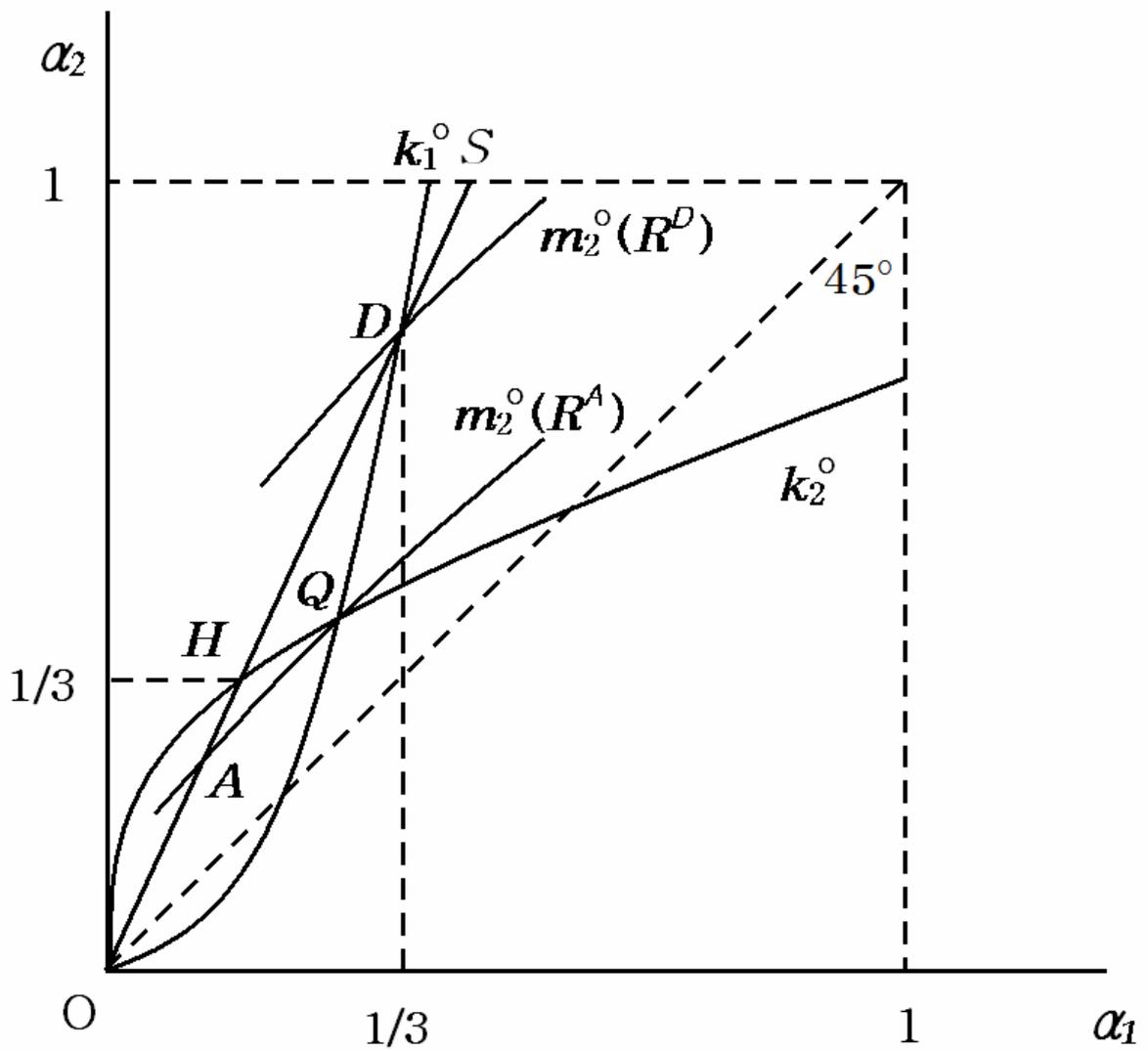


Figure 3. Obtaining α_1^* and α_2^* in the case where $v_1 > v_2$.