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Bridge Burning and Escape Routes*

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Abstract

Thomas Schelling (1966) cites bridge burning as a method of commitment. While such a commitment can increase the chances of success in a conflict, it will generally lower one's payoff if the conflict is lost. I use a standard rent seeking framework and establish conditions under which this type of commitment can raise a player's expected payoff. A necessary condition is that the scale parameter in the rent-seeking function exceed 1. The comparative static effects of bridge burning are never favorable at an interior equilibrium, but the strategy can induce the opponent to concede the outcome of the contest. I also analyze the strategy, associated with Sun Tzu, of leaving an escape path open for your enemy. This strategy always succeeds at an interior equilibrium and raises the expected payoff of both players. Under certain parameter restrictions, leaving an open escape path also has the potential of inducing the opponent to concede the contest. A special case of the model is used to explain why a group subject to a potential transfer might prefer a less efficient tax system to a more efficient system.

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If you are faced with an enemy who thinks you would turn and run if he kept advancing, and if the bridge is there to run across, he may keep advancing. He may advance to the point where, if you do not run, a clash is automatic. Calculating what is in your long-run interest, you may turn and cross the bridge. At least he may expect you to. But if you burn the bridge so that you cannot retreat, and in sheer desperation there is nothing you can do but defend yourself, he has a new calculation to make. Thomas Schelling (1966: 43).

Man, the way I been talking, if I didn't back up my talk I'd have to leave town. I'd have to leave the country. … So I talk big and that just makes me fight harder. Cassius Clay[1]

1. Introduction

In *Arms and Influence*, Thomas Schelling cites bridge burning as a method of commitment.[2] The idea is that troops with no available path for retreat will fight harder. Moreover, if the enemy knows its opponent cannot retreat, it will become discouraged knowing its opponent will fight harder. This may make the enemy more likely to retreat. This is an example of what Schelling (1960: 160) calls a strategic move, whereby a player lowers her payoff in some outcomes of the game in such a way as to achieve a superior outcome overall. However, bridge burning is dangerous. If the battle is lost, defeat will be total because the avenue of retreat has been cut off. In a modeling sense, bridge burning involves lowering one's own payoff in the event one is defeated in a contest. I model this in a standard rent-seeking framework and derive conditions under which bridge burning can succeed. A necessary condition is that the scale parameter in the contest success function be greater than 1.

[1] Later Muhammad Ali. The quote was reproduced in Roberts and Smith (2016: 43).
[2] Bridge burning is referenced in *The Strategy of Conflict* but not addressed in detail as in *Arms and Influence*.

I assume one contestant can increase the level of her losses in the event she is defeated. A voluntary increase in these potential losses is the modeling equivalent of bridge burning. The probability of winning the contest always rises when bridges are burned, but losses are greater in the event of defeat. At an interior equilibrium, the comparative static effects of bridge burning are never favorable for the party engaged in the strategy. However, when the scale parameter in the contest success function exceeds one, there may be a level of losses a contestant can impose upon herself in the event she is defeated in the contest such that her own participation constraint is satisfied while the participation constraint of her opponent is violated. In this case, her opponent will concede the outcome of the contest.

In addition to cutting off one's own path of retreat, a contestant might want to leave open a retreat path for her opponent. This should weaken the opponent's resolve and make it more likely that he will retreat. From a modeling standpoint, this involves lowering the opponent's losses in the event he is defeated. At all interior equilibria, leaving an escape path open raises the expected payoff of the player engaging in the strategy and also raises the expected payoff of her opponent. When the scale parameter in the contest success function is less than 1, leaving an escape path open succeeds where bridge burning definitely would fail. When the scale parameter exceeds 1, it may be feasible to induce the opponent to concede the contest by leaving an open escape path.

An example of leaving an open escape path is providing brutal or corrupt dictators an option of asylum if they step down. de Córdoba (2018) argues that individuals such as Nicolás Maduro in Venezuela and Daniel Ortega in Nicaragua may cling to power because they believe that a peaceful exile free from the fear of arrest is not possible.[3] Among other issues dictators

[3] *Wall Street Journal*, August 4-5, 2018, p. C3.

need to consider is possible prosecution at the International Criminal Court. While such prosecutions may be fully justified, they may lead dictators to hold onto power and spill additional blood because they lack a viable exit option.

A special case of the model may be interpreted as a contest over a transfer payment. Contestant 2 is subject to a potential transfer payable to contestant 1 if she loses the contest. I assume that the net value of the transfer is fixed, but that the gross value depends upon the efficiency of the tax-transfer system. Contestant 2 may prefer a less efficient tax-transfer system if this deters her opponent from engaging in the transfer seeking game. Thus, for example, while value added taxes (VAT) are generally perceived to be efficient, groups subject to potential transfers might oppose such a tax system in favor of one which is less efficient.

As the opening quote from Cassius Clay indicates, there are other metaphorical examples of bridge burning. His quote indicates that his bragging prior to a boxing match increased the costs associated with him losing the match. As a result, he has an incentive to train harder for the match and to fight harder in the match. Dixit and Nalebuff (2008) cite Polaroid's commitment to a single line of business, the instant camera, as an example of corporate bridge burning. They argue that this provided a commitment to fend off potential competitors and cite Polaroid's lengthy court case against Kodak (which Polaroid won) as evidence of this.

Schelling (1960, 1966) places the idea of bridge burning within the context of game theory. The idea of leaving a retreat route open for your enemy may be found in Sun Tzu's *The Art of War*.[4] The contest success function I utilize comes from Tullock (1980). The contest

[4] Also see the discussion in Dixit and Nalebuff (2008: 215-6). As seen in their discussion another frequently given example of commitment is boat burning. Schelling (1966, pp. 44-5) also discusses the strategy of leaving an open escape route.

literature is surveyed by Konrad (2009). The literature on conflict is surveyed by Garfinkel and Skaperdas (2007).[5]

2. The Model

In section 2.1 I will describe the contest. This contest is embedded in a larger game which is described in Section 2.2. The structure of the larger game is designed to allow for the following realistic outcome: If one player's participation constraint is satisfied and the other's is not, the player whose constraint is violated will be allowed to concede the contest to the player whose constraint is satisfied. This cannot be done without adding some additional structure to a standard contest model.

2.1. Contest Description

In this subsection the contest is described. The potential contest between the two players is embedded in a larger game which is fully described in Section 2.2. Let there be two contestants denoted by $i = 1, 2$ and let their respective efforts in the contest be denoted by X_i. The probability p that contestant 1 wins the contest is given by a standard Tullock (1980) function:

$$p = \frac{aX_1^r}{aX_1^r + X_2^r}, \tag{1}$$

where $a > 0$ is a bias parameter and $0 < r < 2$ is a scale parameter. When $a > 1$, the contest is biased in contestant 1's favor and when $a < 1$, it is biased in contestant 2's favor. When $r > 2$ we may have both player's participation constraints violated simultaneously. For $1 < r < 2$, at most

[5] The idea of bridge burning has also been related to entry deterrence in the industrial organization literature. In his discussion of entry deterrence, Tirole (1988: 316) provides an informal discussion of bridge burning within in the context of a military example. As in the current paper, in Tirole's informal example, bridge burning succeeds by discouraging an attack.

one player's participation constraint will be violated. Thus, in order to avoid lengthy discussions about what happens when both constraints are violated, we will utilize the stated restriction on r.[6] The cost of a unit of effort X is normalized to 1.

A key departure from typical analyses along these lines is that I will explicitly model a negative payoff when a player loses the contest.[7] Thus, players obtain R_i^W when they win the contest and suffer the loss R_i^L when they lose, where $i = 1,2$. With the i subscript, I am allowing these payoffs to vary across the players.[8] Note that R_i^L enters negatively into the payoff function. A key assumption of the model is that prior to the contest, player 2 can affect the extent of her own loss R_2^L in the event she is defeated. An act to raise her own loss in the event of defeat is interpreted as bridge burning. Alternatively, I will allow player 2 to lower R_1^L the loss player 1 suffers when he is defeated. This is interpreted as leaving an open escape route.

2.2. The Overall Structure of the Game

The game proceeds as follows:

1.a. Player 2 chooses the loss she incurs in the event she is defeated in the contest, R_2^L. This loss has a minimum value of $\underline{R_2^L}$, but it may be freely increased above this level up to a finite maximum value of $\overline{R_2^L}$.

[6] Equilibria for $r > 2$ in a symmetric contest have been characterized by Alcade and Dahm (2010) and Ewerhart (2015). These are mixed strategy equilibria. The outcomes of these equilibria bear a strong resemblance to the outcomes of the all-pay auction. Analyses of the all-pay auction may be found in Hillman and Samet (1987), Hillman and Riley (1989) and Baye et al. (1996). Ewerhart (2015: 67-70) suggests that similar results will apply for asymmetric contests.

[7] A recent example that considers negative prizes is Liu et al. (2018). They consider negative prizes as part of an optimal contest design to induce maximal effort on the part of the participants.

[8] Nti (1999) analyzes contests where players have asymmetric valuations.

1.b. Player 2 chooses the loss player 1 incurs in the event he loses the contest R_1^L. This loss has an initial value of $\overline{R_1^L}$, but player 2 may reduce this down to a minimum of 0.

2. The contestants decide whether or not to incur an entry fee ε > 0 to potentially participate in the contest at stage 3, where ε is small. If neither player incurs the entry fee, they both receive a payoff of 0. If player 1 incurs the entry fee and player 2 does not, player 1 receives the positive payoff R_1^W, player 2 incurs the loss R_2^L, and no contest takes place. If player 2 incurs the entry fee and player 1 does not, player 1 incurs the loss R_1^L, player 2 receives the positive payoff R_2^W, and no contest takes place. If both incur the entry fee, the game proceeds to step 3.

3. Both players engage in the contest described in Section 2.1.

There is no asymmetric information in this game, so that player 2's choice of either R_2^L or R_2^W at step 1 is observable to player 1 when he makes his participation decision at step 2. I will separately analyze the bridge burning and escape route strategies and in that sense I will be treating steps 1a and 1b as alternatives. Thus, the analysis proceeds as if only one of these strategies is available to player 2 in any given game. The role of the maximal loss $\overline{R_2^L}$ will become apparent later on when I analyze the model.

The entry fee ε is positive but close to zero. From a modeling standpoint, the purpose of the entry fee is to allow a player whose participation constraint is violated at stage 3 to concede the contest at stage 2 by failing to proceed. Given the restriction on *r* at most, only one player will have their participation constraint violated. An outcome in which a player whose participation constraint is violated is able to concede the contest seems quite realistic. Absent an entry fee it would be necessary to describe a semi-mixed strategy equilibrium because even if one party's participation constraint is violated, it is not an equilibrium for the other party to commit only a small level of effort to the contest while the party whose constraint is violated commits to 0 effort. Note the opening quote by Schelling implies that bridge burning, if successful, may prevent an attack from occurring. This is consistent with a failure to proceed at stage 2 of the contest. Thus, the model structure is an appropriate way to capture the idea of bridge burning.

Wang (2010) analyzes an asymmetric Tullock contest where one of the player's participation constraints is violated at the interior pure strategy Nash equilibrium. In the resulting equilibrium, the stronger player employs a pure strategy while the weaker player mixes between zero effort and a positive level of effort. Since the weaker player earns zero when he employs zero effort, in this mixed strategy equilibrium his expected payoff is zero. Thus, if he needed to incur a small fixed cost to participate in the game, he would strictly prefer not to do so, but would instead concede the contest to his stronger opponent. Ewerhart (2017) and Lu (2017) show that the equilibrium identified by Wang is unique. Ewerhart (2017) shows that the equilibrium holds for very general specifications of the contest which encompass the model presented here.

In my game, a player who concedes the contest at stage 2 or who exerts zero effort at stage 3 loses R_i^L instead of zero, but otherwise the results of Wang will apply. If a player foresees that his participation constraint will be violated at stage 3, then he anticipates an expected loss of $R_i^L + \varepsilon$ if he proceeds to that stage. Thus, he would prefer to concede the game at stage 2 where his loss will be R_i^L.

2.3. Model Analysis

In this subsection I will analyze the contest stage including both the interior equilibrium and the player's participation constraints. Before presenting each player's objective function I will make note of some substitutions which will be utilized in the following:

$$R_i^W + R_i^L = R_i,\ i = 1, 2. \tag{2a}$$

$$R_2 / R_1 = R. \tag{2b}$$

Note that R_i constitutes player i's stake in the contest, which is the sum of i's the payoff in the event of victory and i's loss in the event of defeat, while R constitutes the relative stakes. Higher values of R imply the relative stakes favor player 2. With probability p, player 1 wins the contest and receives R_1^W and with probability 1-p, he loses and pays R_1^L. His effort in the contest is denoted X_1. Thus his expected payoff may be expressed as follows: $p(R_1^W + R_1^L) - R_1^L - X_1$. Making use of (1) and (2a), this may be expressed as

$$\Pi_1 = \frac{aX_1^r}{aX_1^r + X_2^r} R_1 - R_1^L - X_1, \tag{3a}$$

where the expected payoff is denoted by Π_1. Since player 2 wins with probability $1-p$ and loses with probability p her expected payoff may be expressed as

$$\Pi_2 = R_2^W - \frac{aX_1^r}{aX_1^r + X_2^r} R_2 - X_2. \tag{3b}$$

Holding effort level constant, an increase in R_2^L will lower player 2's expected payoff through its increase in R_2.

The first order conditions from (3a) and (3b) imply the following solutions for effort levels in the contest:

$$X_1 = \frac{raR^r}{\left(a+R^r\right)^2} R_1, \tag{4a}$$

$$X_2 = \frac{raR^r}{\left(a+R^r\right)^2} R_2, \tag{4b}$$

where use has been made of (2b). Substitute (4a-b) into (1), (3a) and (3b) to obtain the equilibrium payoffs and the equilibrium probability that player 1 prevails:

$$\Pi_1 = \left(\frac{a}{a+R^r}\right)\left(1-\frac{rR^r}{a+R^r}\right)R_1 - R_1^L, \tag{5a}$$

$$\Pi_2 = R_2^W - \left(\frac{a}{a+R^r}\right)\left(1+\frac{rR^r}{a+R^r}\right)R_2, \tag{5b}$$

$$p = \frac{a}{a+R^r}. \tag{5c}$$

Since $R = R_2/R_1$ and $R_2 = R_2^W + R_2^L$, when player 2 increases R_2^L, she lowers p and therefore raises the probability that she wins the contest. When she raises the stakes she faces, she will fight harder in the ensuing contest. From (4a-b), player 2's relative effort X_2/X_1 is increasing in R_2/R_1 and therefore unambiguously increasing in R_2^L. However, we can see from (5b), that in raising R_2 this action increases her losses in the event player 1 wins the contest. Thus, there is a potentially ambiguous effect from increasing R_2^L, which I interpret as bridge burning.

At the time the contest is to be held, the participation constraints for the interior Nash equilibrium require that the expected payoff for each player exceed their payoff if they do not participate in the contest, $-R_i^L$. As we shall see, at most one player's participation constraint will be violated. Thus, for example, if player 1 does not participate in the contest, player 2 will participate and player 1 will lose R_1^L with certainty. Similarly, when player 2 does not participate in the contest, she loses R_2^L with certainty. Note, if a player foresees an expected loss equal to R_i^L at stage 3, he will not incur the cost ε at stage 2 and will concede the contest at that point.[9] By conceding at stage 2, he will incur the loss R_i^L rather than a total loss of $R_i^L + \varepsilon$ if he proceeds to stage 3.

With the above in mind we can use (5a) and (5b) to derive the following participation constraints:[10]

Player 1 Participation Constraint: $a \geq (r-1)R^r$ (6a)

Player 2 Participation Constraint: $R^r \geq (r-1)a$ (6b)

If $r \leq 1$, the constraints of both players are always satisfied. If $1 < r < 2$, at most one participation constraint is violated. For example, if $a < (r-1)R^r$ (player 1's constraint is violated), it is necessarily the case that $R^r > (r-1)a$ (player 2's constraint is satisfied). Since $R = R_2/R_1$, greater values of R make it more likely that player 2's constraint is satisfied and less likely that player 1's constraint is satisfied assuming that $r > 1$.[11] When $r > 1$, both constraints are satisfied if

[9] Recall that the work of Wang (2010) and Ewerhart (2017) imply that there would be a semi-mixed strategy equilibrium in the stage 3 contest at which the disadvantaged player would earn an expected payoff of $-R_i^L$.

[10] These constraints do not take into account the fixed costs ε which are assumed to be close to zero. Rather they simply impose that at the time the contest is to be held, that each player earn an expected payoff greater than $-R_i^L$ at the interior Nash solution reflected in equations (5a-b). Technically however, there are interior Nash equilibria where a player's payoff exceeds $-R_i^L$, but by less than ε, so that he would strictly prefer to concede the game at stage 2. We ignore this possibility because ε is close to zero, but this could be an issue if R_2^L can rise without bound. See footnote 18.

[11] It is important to note that raising R_2^L increases player 2's loss when she loses the contest, but also increases her loss when she concedes the contest. Thus, an increase in R_2^L does not make it less likely that player 2's participation constraint is satisfied. In fact it is just the opposite as the increase in relative stakes makes it more likely that she would like to participate in the contest.

$(r\text{-}1)a \leq R^r \leq a/(r\text{-}1).$ (7)

Using the structure above, we can now present the model results.

2.4. Results

First, consider the impact on player 2's expected payoff of a marginal increase in R_2^L. This corresponds to the case of bridge burning. Taking the derivative of (5b) yields the following:

$$\frac{d\Pi_2}{dR_2^L} = -\left(\frac{a}{\left(a + R^r\right)^3}\right)\left(a^2 + a(2 + r^2)R^r + (1 - r^2)R^{2r}\right). \quad (8)$$

Note that the derivative in (8) will be negative if $r < 1$. Thus, bridge burning is never worthwhile at an interior equilibrium if $r < 1$ because it lowers player 2's expected payoff. However, equation (8) appears to imply that bridge burning will raise player 2's expected payoff if

$$(r^2 - 1)R^{2r} > a^2 + a(2 + r^2)R^r. \quad (9)$$

The inequality in (9) can only hold if $r > 1$. The right-hand side of this expression is increasing in a. Conditional on $r > 1$, from (6a), the lowest possible value of a at an interior equilibrium is $a = (r\text{-}1)R^r$. If we substitute this value of a into (9), we find that the inequality only holds for $r < 1$, yielding a contradiction.[12] If, when $r > 1$, the inequality in (9) cannot hold for the lowest value of a consistent with an interior equilibrium then it cannot hold for any value of a consistent with an interior equilibrium. This, in turn, implies that at an interior equilibrium, the derivative in (8)

[12] In light of the substitution $a = (r\text{-}1)R^r$, $r < 1$ implies $a < 0$, which is not permissible. This would however make the right-hand side of (9) negative, explaining why the inequality would hold when $r < 1$.

is always negative. In other words, bridge burning always reduces player 2's expected payoff at an interior equilibrium.

This analysis is summarized as Result 1:

Result 1: At an interior equilibrium, bridge burning (raising R_2^L) will always reduce player 2's expected payoff.

Result 1 indicates that bridge burning is never desirable based on its comparative static properties.[13] The direct effect of increasing R_2^L is to lower player 2's payoff. Bridge burning raises player 2's relative effort and could be a force leading to higher expected payoffs for player 2. However, Result 1 indicates that these potentially positive effects can never overcome the negative direct effect at an interior equilibrium.

Next suppose that player 2 can lower R_1^L. This captures the idea of leaving an escape route open for your enemy. This makes it easier for him to retreat and will therefore weaken his resolve. From (5b) we obtain the following:

$$\frac{d\Pi_2}{dR_1^L} = -\left(\frac{arR^{1+r}}{\left(a+R^r\right)^3}\right)\left(a(1-r)+R^r(1+r)\right). \tag{10}$$

[13] Suppose that player 1's participation constraint is satisfied, so that *a* > *(r-1)R*^{r}, and that player 2's constraint initially is violated. Further suppose that player 2 can raise R_2^L sufficiently such that her participation constraint is satisfied but that she cannot raise it sufficiently such that player 1's constraint is violated. Would she want to burn bridges under this scenario? The answer is no. Initially she prefers conceding the contest to participating so that the payoff at the interior equilibrium must be less than the initial value of $-R_2^L$. Our prior analysis shows that player 2's payoffs at the interior equilibrium fall with increases in R_2^L, when *a* > *(r-1)R*^{r}. Thus, the payoff at the interior equilibrium that player 2 induces by increasing R_2^L will be lower than her payoff if she initially conceded the contest at the original value of R_2^L.

Keep in mind that the strategy of leaving a path of retreat implies a reduction of R_1^L. Thus, leaving an escape open raises player 2's expected payoff if the derivative in (10) is negative. From (10), we can see that at an interior equilibrium a reduction of R_1^L (i.e., leaving open a path of retreat) always raises player 2's expected payoff when $r \leq 1$. However, equation (10) suggests that leaving an escape route open will lower player 2's expected payoff if

$$R^r(1+r) < a(r-1). \tag{11}$$

Equation (11) can only possibly hold if $r > 1$. If (11) holds, then $d\Pi_2 / dR_1^L > 0$ which implies leaving an escape path open (lowering R_1^L) will lower player 2's expected payoff. From (7), the lowest value of R^r consistent with an interior equilibrium is $R^r = (r\text{-}1)a$, where $r > 1$. Substitute this into (11) to find the condition becomes $r < 1$, which yields a contradiction. If the condition in (11) cannot hold at the lowest value of R^r consistent with an interior equilibrium, it cannot hold at any interior equilibrium. Thus, it is never the case that $d\Pi_2 / dR_1^L > 0$ at an interior equilibrium.

The analysis above is summarized as follows:

<u>Result 2:</u> At an interior equilibrium, leaving an escape path open (i.e., lowering R_1^L) always increases player 2's expected payoff.

Result 2 shows that leaving an escape path always succeeds at an interior equilibrium in the sense of raising player 2's expected payoff.[14] Given the favorable comparative static effects of leaving an escape path open, at stage 1, player 2 would reduce R_1^L down to its minimum value of zero.[15]

Allowing for an escape path lowers the stakes for player 1 and therefore lowers his relative effort level. This raises the probability that player 2 wins the contest and is the source of the gain for player 2. There is no direct negative effect of lowering R_1^L on player 2's payoff. This is in contrast to bridge burning, which has the direct effect of lowering 2's expected payoff. This is the reason for the gains obtained under the strategy of leaving an open escape path.

What is the effect on player 1, when player 2 leaves an open escape path? To see this effect, consider the following derivative of player 1's expected profits:

$$\frac{d\Pi_1}{dR_1^L} = \left(\frac{a}{(a+R^r)^3}\right)\left[a^2 + a(2+r^2)R^r + (1-r^2)R^{2r}\right] - 1. \tag{12}$$

When player 2 leaves an open escape path, she lowers R_1^L. Thus, player 1 will benefit from this strategy if the derivative in (12) is negative. This derivative is negative if

$$ar^2\left(a - R^r\right) < \left(a + R^r\right)^2. \tag{13}$$

[14] Suppose that initially player 2's constraint is violated and player 1's is not. Would player 2 want to lower R_1^L in order to allow her constraint to be satisfied? The answer is yes. Since R_2^L is constant in this scenario, player 2 can only cause her constraint to hold if she raises her payoff above the fixed value -R_2^L at the interior equilibrium and this unambiguously make her better off. This contrasts with bridge burning where player 2 is increasing R_2^L and will make herself worse off even though changes in R_2^L can induce her participation constraint to hold. See footnote 13.

[15] Nothing of substance is changed if we assume this minimum value lies above zero, though a minimum value above zero would affect the precise expressions presented below in Result 5.

This condition will clearly hold if $r < 1$. Consider $r > 1$ and note that the condition is more likely to hold the larger is R^r. From equation (6b), the lowest value of R^r consistent with an interior equilibrium is $R^r = (r\text{-}1)a$. Substitute this into (13) to find that the needed condition holds whenever $r > 1$ as was our initial assumption. Since this holds for the smallest value of R^r consistent with an interior equilibrium, it will hold at all interior equilibria. This leads to Result 3:

> Result 3: At an interior equilibrium, player 1 always benefits when player 2 leaves him an open escape path.

Leaving an open escape route is a positive sum maneuver in the sense that it makes both players better off.[16] The fact that player 1 loses less in the event of defeat creates a surplus which the two players may split.

Results 1 and 2 show that at an interior equilibrium leaving an open escape path is always a successful strategy and that bridge burning is never successful. However, as we shall see, once participation constraints are taken into account, a bridge burning strategy may be successful when $r > 1$. From (6a), if $r < 1$ player 1's participation constraint is always met and bridge burning cannot succeed.

Suppose $r > 1$ and consider two cases defined by the maximal loss that player 2 can impose upon herself $\overline{R_2^L}$:

(i) $\overline{R_2^L} > \left(a/[r-1]\right)^{(1/r)}\left(R_1^W + \overline{R_1^L}\right) - R_2^W$ and

[16] Because the analysis indicates that player 2 will never utilize the bridge burning strategy at an interior equilibrium, I have not presented the derivative showing the effect of such a strategy on player 1. However, it can be shown that such a strategy would lower player 1's expected payoff. Thus, if it were invoked at an interior equilibrium, bridge burning would make both players worse off.

(ii) $\overline{R_2^L} \le \left(a/[r-1]\right)^{(1/r)}\left(R_1^W + \overline{R_1^L}\right) - R_2^W$.

Recall that $R = R_2/R_1$ and $R_i = R_i^W + R_i^L$. Let $\overline{R}$ be the highest possible value of R. When condition (i) holds, then $(r-1)\overline{R^r} > a$ and when condition (ii) holds $(r-1)\overline{R^r} \le a$.[17] When condition (i) holds, then from (6a-b) we see that it is possible for player 2 to choose a large enough value of R_2^L such that her constraint in (6b) is satisfied while player 1's constraint in (6a) is violated. Under these conditions, bridge burning can always be made into a successful strategy by inducing player 1 to concede the contest. However, when condition (ii) holds, player 2 cannot induce player 1 to concede the contest and the bridge burning strategy will not be employed. The analysis above is summarized as follows:

> Result 4 (a) When $r < 1$, bridge burning is never a desirable strategy. (b) Assume $r > 1$. When $\overline{R_2^L}$ is sufficiently large as defined by condition (i), it is always possible to identify a successful bridge burning strategy under which player 2's participation constraint is satisfied, while player 1's constraint is violated. When $\overline{R_2^L}$ is sufficiently small as defined by condition (ii), player 2 cannot induce player 1 to concede the contest and the bridge burning strategy is not employed.

When $r > 1$, a player will concede the contest if it is sufficiently unbalanced. Thus, the needed conditions on $\overline{R_2^L}$ are required to ensure that player 2 can create a sufficiently unbalanced contest such that player 1 will concede.[18]

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[17] Recall we are assuming $r > 1$.

[18] In the statement of the game it is assumed that $\overline{R_2^L}$ is finite. If R_2^L can be increased without bound, then bridge burning can succeed even if $r < 1$. From (5a), if R can be increased without bound, then at some point we will have $\prod_1 - \varepsilon < - R_1^L$. At this point, player 1 would prefer to concede at stage 2 rather than proceed to the contest. In

Leaving an escape path open can also cause player 1's participation constraint to fail. Assuming that player 2 can reduce R_1^L to 0, the following are the crucial conditions:

(iii) $(r-1)\left(\dfrac{\underline{\underline{R_2^L}} + R_2^W}{R_1^W}\right)^r > a$

(iv) $(r-1)\left(\dfrac{\underline{\underline{R_2^L}} + R_2^W}{R_1^W}\right)^r \leq a$

Note that the term in the large parentheses in each expression is $\overline{R}$, the largest value of R which can be obtained by leaving an open escape path. From (6a-b) we can see that when (iii) holds, player 2 can induce player 1 to concede the contest via the strategy of leaving an open escape path. The condition in (iii) can only hold if $r > 1$. When the condition in (iv) holds, player 2 cannot induce player 1 to concede the contest via this strategy. The analysis above is summarized as follows:

> <u>Result 5:</u> (a) When condition (iii) holds, player 2 can induce player 1 to concede the contest by leaving an open escape path, i.e., by reducing R_1^L, possibly down to its minimum value of 0. A necessary condition for (iii) to hold is $r > 1$. (b) When the condition in (iv) holds, player 2 cannot induce player 1 to concede the contest by leaving an open escape path. A sufficient condition for (iv) to hold is $r \leq 1$.

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assuming $\overline{R_2^L}$ is finite and that ε is near zero, I am implicitly assuming that this cannot occur in the game I have specified. If we allow that fixed costs ε could be large or that $\overline{R_2^L}$ could become infinite, then this case would become relevant. This would enlarge the circumstances under which bridge burning would be effective.

Lowering R_1^L raises the relative stakes R in player 2's favor. When condition (iii) is met it is feasible to raise the relative stakes sufficiently as to get player 1 to concede the contest. Thus, bridge burning and leaving an open escape path both have the potential to succeed by inducing a concession from player 1. However, only leaving an open escape path can succeed at an interior equilibrium. Moreover, leaving an escape path open can succeed (via a positive comparative static effect) in a portion of the parameter space, $r < 1$, in which bridge burning can never succeed.

2.5. A Special Case: A Transfer Seeking Game

Consider a special case of the model in which player 1 attempts to extract a transfer from player 2. If player 1 is successful he obtains R_1^W and if he is unsuccessful he obtains $R_1^L = 0$. If player 2 wins the contest she receives the payoff $R_2^W = 0$ and if she loses the contest she pays $R_2^L = (1+\delta)R_1^W$. Thus, player 2 pays what player 1 receives times $1+\delta$, where δ reflects distortions associated with the tax-transfer system.[19] Since these represent specific parameters for the more general model presented earlier, all the previous analysis goes through. Since $R_1^L = 0$ in the transfer game, "leaving an escape open" is not an option in this game, but if player 2 can control the size of the distortion δ, she can increase R_2^L and utilize a bridge burning strategy. As seen previously, this strategy is ineffective if $r \leq 1$. However, if $r > 1$ then a large enough value

[19] The transfer game as specified has only two players. If we have a group 1 with n_1 identical players and a group 2 with n_2 identical players, then the transfer paid by each member of group 2 in the event of a loss would be $R_2^L = (1+\delta)R_1^W n_1 / n_2$. Adding the constant n_1/n_2 to the model would not affect any conclusions. With many members, each group would be subject to a free-rider problem. When there are no income effects, as in the current model, within each group only the player with the largest stakes in the contest will contribute. If players are identical, aggregate contributions from the group are equivalent to the contributions a single individual would make. These results are related to Olson's (1965) exploitation of the great by the small result and his group-size paradox. See the discussions of these issues in Sandler (2015), Buchhotz and Sandler (2016), and Pecorino (2015, 2016). Consideration of a free-rider problem would not affect the conclusions discussed in the main text.

of δ can ensure that player 2's participation constraint is satisfied while player 1's constraint is violated.

A higher value of δ implies a less efficient tax system. Thus, the model suggests at least some circumstances under which a party potentially subject to a transfer prefers a less efficient tax-transfer system. The reason is that (relative to their opponent) they will fight harder to resist transfers under such a system and this might prevent player 1 from seeking the transfer (i.e., with a large enough value of δ, player 1's participation constraint will be violated.). This corresponds in at least a rough way with conservative suspicions of a value added tax (VAT) based on the concern that such a tax can too easily raise large sums of money for the government.[20]

Of course, a group subject to a transfer does not directly control δ. What the analysis suggests is that if lobbying over the nature of the tax system precedes lobbying over the transfer, then the group potentially subject to the transfer may lobby for the enactment of a less efficient tax system.

3. Conclusion

This paper formalizes the ideas of bridge burning and of leaving your opponent an open escape path within the familiar rent-seeking framework. This is accomplished by explicitly considering the negative payoff each party suffers when they lose the contest. Bridge burning can be successful when the scale parameter in the contest success function exceeds one. When this is true, a player may be able to find a high enough value of her own loss such that her participation constraint is satisfied, while the participation constraint of her competitor is violated. When bridge burning succeeds it does so by inducing the other player to concede the contest. It never

[20] This point is discussed by Dorfman (2016).

has favorable comparative static properties at an interior equilibrium for the player utilizing the strategy. For bridge burning to succeed, the player needs to be able to impose a sufficiently high level of costs upon herself in the event of defeat. Note that bridge burning never succeeds when the scale parameter is less than or equal to one. By contrast, leaving an escape path open always raises a players expected payoff at an interior equilibrium. This strategy can succeed in a portion of the parameter space (a scale parameter less than 1) in which bridge burning always fails. It is also a positive sum strategy as it raises the expected payoffs of both players at an interior equilibrium. Moreover, leaving an open escape path can also possibly induce the opponent to concede the contest if the scale parameter is greater than 1.

While the paper establishes that bridge burning and leaving an escape route can be successful within the familiar rent-seeking framework, certain important caveats are in order. First, it is assumed that bridge burning lowers one's own payoff, but does not raise the opponent's payoff. This might be the case in a one off battle, but if the battle is part of a larger engagement, then the greater losses you suffer as a result of bridge burning will benefit your opponent in future engagements. This then raises the stakes of the current engagement for your opponent. A similar caveat applies to the idea that trash talking can motivate one's self to compete harder. Yip et al. (2018) have shown experimentally that trash talking can motivate your opponent to fight harder as well. If burning a bridge raises your opponent's payoff it will not lead to a failure of his participation constraint. Similarly, while leaving an escape path open will reduce your opponent's loss in the event he loses, it may reduce your own payoff in the event you win, if you need to battle your opponent again at some future point. Dixit and Nalebuff (2008: 224) frame Sun Tzu's strategy as fooling the enemy into thinking there is an escape path, but then ambushing them during the retreat. This suggests a concern for future engagements.

While these caveats are important, this paper has shown in a standard framework that these two famous strategies, bridge burning and leaving an open escape path, can be successful under a wide range of circumstances.

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