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The Paradox of Revenge in Conflicts

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Abstract

The authors consider a two-period game of conflict between two factions, which have a desire for revenge. It is shown that, in contrast to conventional wisdom, the desire for revenge need not lead to escalation of the conflict. The subgame-perfect equilibrium is characterized by two effects: a value of revenge effect (i.e., the benefit of exacting revenge) and a self-deterrence effect (i.e., the fear of an opponent's desire to exact revenge). The authors construct examples where the equilibrium is such that the self-deterrence effect paradoxically outweighs the value effect and thereby decreases the factions' aggregate effort below the level exerted in the no-revenge case. This paradox of revenge is more likely, the more elastically the benefit of revenge reacts to the destruction suffered in the past and the more asymmetric is the conflict. The authors discuss the implications of revenge-dependent preferences for welfare economics, evolutionary stability, and their strategic value as commitment devices.

Keywords

conflict, paradox, revenge, subgame-perfect equilibrium

> If it will feed nothing else, it will feed my revenge.
> William Shakespeare, *The Merchant of Venice* (Shylock act III)

> Revenge is profitable.
> Edward Gibbon, *Decline and Fall of the Roman Empire* (chap XI)

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The desire for revenge appears to be a common human trait. As Elster (1990, 862) observes "[R]evenge—the attempt, at some cost or risk to oneself, to impose suffering upon those who have made one suffer, because they made one suffer—is a universal phenomenon."[1] De Quervain et al. (2004) found that the striatum, a key subcortical brain structure involved in feeling satisfaction, was activated in human volunteers subjected to positron emission tomography (PET) imaging as they played a game designed to elicit acts of revenge (see also Knutson 2004). Moreover, in pre-industrial societies, revenge was seen as an integral part of justice and retribution. This still persists in certain societies. Indeed, some people justify capital punishment on the grounds that someone who has taken another human being's life deserves to have his life taken (i.e., an eye for an eye). See, for example, Nussbaum (1999, 157-58) for a discussion.

Revenge is often seen as a major cause of continuing conflict over and beyond the original cause of the conflict (see, e.g., Chagnon 1988; Kim and Smith 1993; Juah 2002). Even more, it is sometimes argued that the desire for revenge may completely destabilize a conflict since an action by one faction is countered by an action of the other faction, which is again countered by the first faction and so on. Each faction in the conflict may want to "throw the last punch." Hence, so the argument goes, revenge may lead to escalation of the conflict with dramatic or even devastating consequences for all factions. For example, commenting on the notoriously famous and bloody nineteenth-century feud along the Kentucky–West Virginia backcountry involving the families of the Hatfields and McCoys,[2] Frank (1988, 1) observed that "[T]o this day, no one is sure how it actually started. But once underway, its pattern was one of alternating attacks, each a retaliation for the preceding, and thus also the provocation for the one to follow."

The interesting point of this article is that, in contrast to the above arguments, the desire for seeking revenge need not lead to escalation of the conflict. Paradoxically, revenge itself even may be a reason why the conflict is less destructive. We consider a two-period game of conflict between two factions competing over a given resource. Each faction has a desire to exact revenge for past destruction suffered. The benefit of exacting revenge in period 2 is increasing in the destructive efforts suffered in period 1. If in period 2 a faction wins the conflict, it gets utility from exacting revenge. Hence, in our model the desire for revenge is understood as a "prize-enhancing" phenomenon.

The subgame-perfect equilibrium of this conflict game is characterized by two effects: a value of revenge effect (i.e., the benefit of exacting revenge) and a self-deterrence effect (i.e., the fear of an opponent's desire to exact revenge). We construct examples where the equilibrium is such that the self-deterrence effect paradoxically outweighs the value effect and thereby decreases the factions' aggregate effort below the level exerted in the no-revenge case. This is what we call the *paradox of revenge* because the desire for retaliation reduces the aggregate cost of the conflict. We show that the paradox is more likely, the more elastically the benefit of revenge reacts to the destruction suffered in the past and the more asymmetric is the conflict.

Our paradox of revenge result is important. Revenge is often seen as a major destabilizing element in conflicts. The consequences are expected to be dramatic for the factions with a total loss of human life and property. Our results show that this may not be true, but that revenge itself may be a reason why conflicts are stabilized. Such a result may help explain why devastating conflicts eventually become stabilized even though it is known that the factions have a desire for retaliation. A good example may be the conflict between Protestants and Catholics in Ireland. After a long time of action and counteraction, today the effort levels of the two factions are rather low, and the conflict seems to be almost resolved. Of course, there may be other reasons for the resolution of the conflict (e.g., third-party intervention, faction asymmetries), but the self-deterrence effect identified in our analysis may also contribute to the explanation of this observation, in particular since we show that this effect is the more important, the more asymmetric is the conflict. A similar line of reasoning may be applied to the end of the cold war between the NATO (North Atlantic Treaty Organization) countries and the members of the Warsaw Pact during the nineties.

The preceding point implies that revenge plays a role analogous to tit-for-tat strategies in repeated prisoner dilemma type games insofar the desire to exact revenge (i.e., punishment) may lead to socially desirable or cooperative outcomes. However, a key difference between tit-for-tat strategy and exacting revenge (as modeled in this article) is that in tit-for-tat, the player who retaliates does not derive utility from the revenge per se. He only derives a positive utility if his retaliatory action causes his opponent to cooperate in the future. Hence, tit-for-tat—as modeled in repeated games—is forward-looking[3] while exacting revenge—as modeled in this article and in reality—is backward-looking.[4] This distinction is akin to the legal and philosophical discussions of punishment for the purpose of deterrence and reform vis-à-vis punishment for the purpose of atonement (justice). It is the basis of the legal debate on the merits of retributive justice vis-à-vis restorative justice. This difference in perspectives explains why some South Africans were not satisfied with the mandate and job of the Truth and Reconciliation Commission[5] in postapartheid South Africa.

Since in our model the desire for seeking revenge is motivated by the past, it goes against economists' intuition of letting bygones be bygones. In standard economics, it is usually argued that sunk costs should not matter. However, in reality sunk costs matter.[6] And one such example is the desire to exact revenge. This desire may stem from preferences that reflect loss aversion (Kahneman and Tversky 1979). For example, in a war, one may want to exact revenge because not doing so is tantamount to losing the war (McAfee, Hugo, and Mialon 2010).

There is, of course, a literature that studies the conditions under which conflicts escalate or end. Examples are Nalebuff (1986), Fearon (1994), Carlson (1995), Bester and Konrad (2005), Konrad and Kovenock (2005), and Hausken (2008). Carment and Rowlands (1998); Siqueira (2003); Chang, Joel, and Sanders (2007); and Amegashie and Kutsoati (2007) examine third-party intervention in conflicts. Garfinkel and Skarpedas (2000) study how conflict can arise in a world of complete information, and Skaperdas (1992) investigated the conditions for peace and conflict in world with no property rights. But none of these studies has focused on the role of a desire for revenge.[7]

The article is organized as follows. The next section presents a two-period game of a conflict between two factions that have a desire for revenge. As a benchmark, we then derive the equilibrium in the case where the factions do not obtain a benefit from retaliation. Thereafter, the subgame-perfect equilibrium of the game with revenge is characterized. The final sections discuss the results and conclude.

A Model of Revenge in Conflicts

Consider two factions in a two-period conflict (war). The time index is $t = 1, 2$ and we use $j, k = 1, 2$ as faction indices, where $j \neq k$ if not stated otherwise. The original cause of the conflict is a given resource. For example, in the Israeli–Palestinian conflict, the resource may be land that is used for settlements. The factions compete for this resource in period 1 and whoever wins the resource in this period keeps it. However, in period 2, the factions could engage in conflict to exact revenge for atrocities suffered in period 1. The game ends after period 2.[8]

Denote the effort that faction j expends in order to win the conflict in period t by x_{jt}. The cost of exerting this effort is linear and we normalize the unit cost to one, so cost of effort equals effort x_{jt} itself. Faction j values the resource in the first period by V_j. Faction j's value of revenge in period 2 is given by $R_j(x_{k1})$ where

$$R_j(x_{k1}) > 0, \ \text{if}\, x_{k1} > 0, \tag{1}$$

$$R_j(x_{k1}) = 0, \ \text{if}\, x_{k1} = 0, \tag{2}$$

$$\mathrm{R}'_j(x_{k1}) > 0. \tag{3}$$

Equation (1) means that faction j has a positive valuation for revenge, if the previous destruction of its property and human life caused by the other faction k is positive. According to equation (2), the valuation is zero, if there has not been any loss of human lives or property. Equation (3) states that the higher the previous destruction suffered, the higher the value of revenge.[9]

The probability that faction j wins the conflict in period t is given by the contest success function

$$P_{jt} = \frac{x_{jt}^{\eta}}{x_{jt}^{\eta} + x_{kt}^{\eta}}. \tag{4}$$

Equation (4) represents the standard Tullock contest success function frequently used in conflict models. The parameter $\eta > 0$ reflects the discriminatory power of the contest. It shows how sensitive the winning probabilities of the factions react to changes in effort levels.

Equilibrium without Revenge

As a benchmark we consider the case without revenge. If there is no revenge then, given our assumptions, there will be conflict in period 1 but not in period 2. Thus, faction j's equilibrium effort in period 2 and total equilibrium effort in period 2 are given by

$$\tilde{x}_{j2} = 0, \tilde{X}_2 = \tilde{x}_{j2} + \tilde{x}_{k2} = 0, \quad 5$$

where the tilde indicates the equilibrium in case without revenge. The payoff of faction j in period 1 can be written as

$$\pi_{j1} = \frac{x_{j1}^{\eta}}{x_{j1}^{\eta} + x_{k1}^{\eta}} V_j - x_{j1}. \quad 6$$

Faction j maximizes equation (6) with respect to effort x_{j1} taken as given x_{k1}. Differentiating gives the first- and second-order conditions

$$\frac{d\pi_{j1}}{dx_{j1}} = \frac{\eta x_{j1}^{\eta-1} x_{k1}^{\eta}}{(x_{j1}^{\eta} + x_{k1}^{\eta})^2} V_j - 1 = 0, \quad 7$$

$$\frac{d^2\pi_{j1}}{dx_{j1}^2} = \eta V_j x_{j1}^{\eta-2} x_{k1}^{\eta} \frac{(\eta - 1)x_{k1}^{\eta} - (\eta + 1)x_{j1}^{\eta}}{(x_{j1}^{\eta} + x_{k1}^{\eta})^3} < 0. \quad 8$$

Solving condition (7) and the corresponding condition for faction k with respect to the x_{j1} and x_{k1} gives the equilibrium first period effort levels[10]

$$\tilde{x}_{j1} = \frac{\eta V_j^{\eta+1} V_k^{\eta}}{(V_j^{\eta} + V_k^{\eta})^2}, \tilde{X}_1 = \tilde{x}_{j1} + \tilde{x}_{k1} = \frac{\eta V_j^{\eta} V_k^{\eta} (V_j + V_k)}{(V_j^{\eta} + V_k^{\eta})^2}. \quad 9$$

The equilibrium aggregate effort exacted by the two faction in both periods is obtained from equations (5) and (9) as

$$\tilde{X} = \tilde{X}_1 + \tilde{X}_2 = \frac{\eta V_j^{\eta} V_k^{\eta} (V_j + V_k)}{(V_j^{\eta} + V_k^{\eta})^2}. \quad 10$$

This expression will serve as benchmark when we now turn to the case with revenge.

Equilibrium with Revenge

If the factions are motivated by a desire for revenge, there is conflict in the first and second period. In order to ensure a subgame-perfect Nash equilibrium, we work backward by solving the game in period 2 conditional on x_{j1} and x_{k1} having been exerted in period 1 by the two factions. In period 2, faction j chooses x_{j2} to maximize its payoff

$$\pi_{j2} = \frac{x_{j2}^{\eta}}{x_{j2}^{\eta} + x_{k2}^{\eta}} R_j(x_{k1}) - x_{j2}. \tag{11}$$

The period 2 conflict described by equation (11) is structurally equivalent to the period 1 conflict in the absence of revenge described in the previous section by equation (6). We only have to change the time index from 1 to 2 and replace the valuation V_j by the benefit of revenge $R_j(x_{k1})$. Hence, the first- and second-order conditions for the maximization of equation (11) are immediately obtained from their counterparts in equations (7) and (8). Similar to equation (9), the first-order conditions yield the equilibrium second period effort of faction j and the equilibrium second period total effort as

$$\hat{x}_{j2} = \frac{\eta R_j(x_{k1})^{\eta+1} R_k(x_{j1})^{\eta}}{[R_j(x_{k1})^{\eta} + R_k(x_{j1})^{\eta}]^2}, \tag{12}$$

$$\hat{X}_2 = \hat{x}_{j2} + \hat{x}_{k2} = \frac{\eta R_j(x_{k1})^{\eta} R_k(x_{j1})^{\eta} [R_j(x_{k1}) + R_k(x_{j1})]}{[R_j(x_{k1})^{\eta} + R_k(x_{j1})^{\eta}]^2}, \tag{13}$$

where the hat denotes equilibrium values when the factions have a desire for revenge.

Equation (12) already indicates the *value effect* of revenge. When the factions do not have a desire for revenge, we know from equation (5) that the second period effort is zero. In contrast, a positive benefit from exacting revenge renders the second period effort levels of both factions positive according to equation (12). Formally, $R_j = R_k = 0$ implies $x_{j2} = x_{k2} = 0$, whereas for $R_j > 0$ and $R_k > 0$ we obtain $x_{j2} > 0$ and $x_{k2} > 0$.

Inserting equation (12) into equation (11) gives faction j's second period equilibrium payoff as a function of the first period effort levels; that is,

$$\hat{\pi}_{j2} = \frac{R_j(x_{k1})^{2\eta+1} + (1-\eta) R_j(x_{K1})^{\eta+1} R_k(x_{j1})^{\eta}}{[R_j(x_{k1})^{\eta} + R_k(x_{j1})^{\eta}]^2}. \tag{14}$$

For the analysis to follow, we need to know the impact of faction j's first period effort on faction j's second period equilibrium payoff. Differentiating equation (14) gives

$$\frac{d\hat{\pi}_{j2}}{dx_{j1}} = \frac{\eta R_j^{\eta+1} R_k^{\eta-1} R'_k [(1+\eta) R_j^{\eta} + (1-\eta) R_k^{\eta}]}{[R_j^{\eta} + R_k^{\eta}]^3} < 0, \tag{15}$$

where, for notational convenience, we suppressed the arguments of the revenge functions. The sign of equation (15) follows from $(1+\eta)\mathrm{R}_j^{\eta} + (1-\eta)\mathrm{R}_k^{\eta} < 0$

which, in turn, follows from the second-order condition of the maximization of equation (11).[11] According to equation (15), an increase in faction j's first period effort reduces this faction's second period payoff. The intuition is that, because of the desire of revenge, faction k fights harder in the second period conflict when faction j invests more effort in the initial first period conflict over the resource. This property is the basis for the self-deterrence effect which we will derive in the following.

We are now in the position to analyze the period 1 conflict. Faction j chooses x_{j1} to maximize the present value of its payoff from both periods given by

$$\pi_{j1} = \frac{x_{j1}^{\eta}}{x_{j1}^{\eta} + x_{k1}^{\eta}} V_j + \hat{\pi}_{j2} - x_{j1}. \qquad 16$$

The first-order condition of this maximization problem reads[12]

$$\frac{d\pi_{j1}}{dx_{j1}} = \frac{\eta x_{j1}^{\eta-1} x_{k1}^{\eta}}{(x_{j1}^{\eta} + x_{k1}^{\eta})^2} V_j + \frac{d\hat{\pi}_{j2}}{dx_{j1}} - 1 = 0. \qquad 17$$

The decisive difference to the corresponding condition (7) in the absence of revenge is the second term in equation (17). According to equation (15), this new term is always negative. Thus, when the factions have a desire for revenge, the derivative in equation (17), evaluated at the equilibrium of the no-revenge case, is negative. Hence, each faction's effort in period 1 is lower when there is revenge than when there is no revenge. Anticipating that its effort in period 1 will cause faction k to exact revenge in period 2 induces faction j to reduce its effort in the conflict over the resource. This is the *self-deterrence effect* of revenge.

In sum, we have shown so far that the desire for revenge causes two effects that are not present in the no-revenge case: the value effect represented by equation (12) and the self-deterrence effect represented by the second term in equation (17). These two effects have opposing impact on the aggregate effort spent by both factions in both periods. When the value effect outweighs the self-deterrence effect, total effort of the factions will be higher in the revenge case than in the no-revenge case. This is the basic notion that revenge will escalate the conflict. However, if the self-deterrence effect is stronger than the value effect, then revenge will paradoxically render the conflict less destructive. This is what we call the *paradox of revenge* in conflicts.

In order to present examples where the paradox emerges and to investigate the causes of the paradox, we now consider a number of special cases. Let us start with the perfectly symmetric case where both factions have the same valuation $V_j = V$ and the same isoelastic revenge function $R_j(x_{k1}) = R(x_{k1}) = \alpha x_{k1}^{\theta}$ with $\alpha > 0$ and with $\theta > 0$ representing the elasticity of one faction's benefit of revenge with respect to the other faction's first period effort. Denoting aggregate effort spent by both factions in both periods in the presence of revenge by $\hat{X}$, we can prove

Proposition 1: Suppose $V_j = V$ and $R_j(x_{k1}) = R(x_{k1}) = \alpha x_{k1}^{\theta}$ with $\alpha > 0$ and $\theta > 0$. Then $\hat{X} \lesseqgtr \tilde{X}$ if and only if $\theta \gtreqless 1$.

Proof: Note first that for $V_j = V$ and $R_j(x_{k1}) = R(x_{k1}) = \alpha x_{k1}^{\theta}$ we have a symmetric equilibrium with $\hat{x}_{j1} = \hat{x}_1$. Equations (13) and (15) then reduce to

$$\hat{X}_2 = \frac{\eta\alpha\hat{x}_1^{\theta}}{2}, \; \frac{d\hat{\pi}_{j2}}{dx_{j1}} = -\frac{\eta\alpha\theta\hat{x}_1^{\theta-1}}{4}.$$

Inserting the second expression into equation (17) and rearranging gives the implicit solution for the first period equilibrium effort level

$$\hat{x}_1 = \frac{\eta V}{4} - \frac{\eta\alpha\theta\hat{x}_1^{\theta}}{4}.$$

The total effort in case of revenge can therefore be written as

$$\hat{X} = 2\hat{x}_1 + \hat{X}_2 = \frac{\eta V}{2} + (1-\theta)\frac{\eta\alpha\hat{x}_1^{\theta}}{2}.$$

Comparing this expression with $\tilde{X} = \eta V/2$, which follows from equation (10) and $V_j = V$ immediately proves the proposition. (Q.E.D.)

Proposition 1 states that in the fully symmetric conflict the paradox of revenge emerges if the relationship between the benefit of revenge and the previous destructive effort of one's enemy is elastic ($\theta > 1$). In contrast, for an inelastic relationship ($\theta < 1$) the desire for revenge escalates the conflict, whereas revenge is neutral with respect to aggregate effort in case of a unit elasticity ($\theta = 1$). These results have a strong economic intuition, since the self-deterrence effect is positively correlated with the elasticity of the benefit of revenge. In the elastic range ($\theta > 1$) one faction's benefit of revenge increases overproportionally if past destruction of its enemy is raised. Hence, the faction has a strong incentive to strike back in the second period conflict. This, in turn, gives the enemy a strong incentive to lower first period effort and to avoid retaliation, so the self-deterrence effect is relatively strong and overcompensates the value effect. This argument is reversed in the inelastic range ($\theta < 1$), and for unit elasticity the self-deterrence effect and the value effect just neutralize each other.

Interestingly, the insights obtained by Proposition 1 are independent of the discriminatory power η of the conflict. That means that, under the conditions of Proposition 1, the exact shape of the contest success function is irrelevant for the question whether the paradox of revenge emerges or not. The reason is as follows. The discriminatory power η influences the effort spent in the conflict, indeed. The higher η, the more sensitive are the factions' winning probabilities with respect to changes in effort and, thus, the more effort is spent by the factions in equilibrium. However, this is true both in the presence and in the absence of revenge. Hence, in both cases, a change in the discriminatory power η changes total effort in the same way. The comparison of aggregate effort in the two cases is therefore independent of η. Motivated by this property we set $\eta = 1$ in the rest of the analysis.

Next we turn to the impact of faction asymmetries on the paradox result. There are basically two sources of asymmetries: the valuation of the resource and the benefit from exacting revenge. Let us start with differences in the benefit of revenge. In order to isolate the role of such asymmetries, we set the elasticity of the benefit from exacting revenge equal to one ($\theta = 1$). Hence, according to Proposition 1, starting from a fully symmetric conflict means that we start in a situation where the aggregate effort is the same with and without revenge. Then, introducing differences in the benefits of revenge allows us to find out whether such asymmetries make the paradox more or less likely. Formally, suppose $V_j = V$ and $R_j(x_{k1}) = \alpha_j x_{k1}$ with $\alpha_j \neq \alpha_k$. We then obtain

Proposition 2: Suppose $\eta = 1$, $V_j = V$ and $R_j(x_{k1}) = \alpha_j x_{k1}$ with $\alpha_j \neq \alpha_k$. Then $\hat{X} < \tilde{X}$.

Proof: Equations (13) and (15) can now be written as

$$\hat{X}_2 = \frac{\alpha_j \hat{x}_{k1} \alpha_k \hat{x}_{j1}}{\alpha_j \hat{x}_{k1} + \alpha_k \hat{x}_{j1}}, \frac{d\hat{\pi}_{j2}}{dx_{j1}} = -\frac{2\alpha_k \alpha_j^3 \hat{x}_{k1}^3}{(\alpha_j \hat{x}_{k1} + \alpha_k \hat{x}_{j1})^3}.$$

Putting the second expression into the first-order condition (17) shows that $\alpha_j \neq \alpha_k$ implies $\hat{x}_{j1} \neq \hat{x}_{k1}$, since otherwise we obtain a contradiction. Rearranging equation (17) yields the implicit solutions for the first period equilibrium effort levels; that is,

$$\hat{x}_{j1} = \frac{\hat{x}_{j1}\hat{x}_{k1} V}{(\hat{x}_{j1} + \hat{x}_{k1})^2} - \frac{2\alpha_k \hat{x}_{j1} \alpha_j^3 \hat{x}_{k1}^3}{(\alpha_j \hat{x}_{k1} + \alpha_k \hat{x}_{j1})^3}, \hat{x}_{k1} = \frac{\hat{x}_{j1}\hat{x}_{k1} V}{(\hat{x}_{j1} + \hat{x}_{k1})^2} - \frac{2\alpha_j \hat{x}_{k1} \alpha_k^3 \hat{x}_{j1}^3}{(\alpha_j \hat{x}_{k1} + \alpha_k \hat{x}_{j1})^3}.$$

Aggregate effort in case of revenge is

$$\hat{X} = \hat{x}_{j1} + \hat{x}_{k1} + \hat{X}_2 = \frac{2\hat{x}_{j1}\hat{x}_{k1} V}{(\hat{x}_{j1} + \hat{x}_{k1})^2} - \frac{\alpha_k \hat{x}_{j1} \alpha_j \hat{x}_{k1} (\alpha_j \hat{x}_{k1} - \alpha_k \hat{x}_{j1})^2}{(\alpha_j \hat{x}_{k1} + \alpha_k \hat{x}_{j1})^3}.$$

Equation (10) and $V_j = V$ imply $\tilde{X} = V/2$. Hence, $\hat{X} < \tilde{X}$ if and only if

$$-\frac{(\hat{x}_{j1} - \hat{x}_{k1})^2 V}{2(\hat{x}_{j1} + \hat{x}_{k1})^2} - \frac{\alpha_k \hat{x}_{j1} \alpha_j \hat{x}_{k1} (\alpha_j \hat{x}_{k1} - \alpha_k \hat{x}_{j1})^2}{(\alpha_j \hat{x}_{k1} + \alpha_k \hat{x}_{j1})^3} < 0.$$

This condition is always satisfied. (Q.E.D.)

Proposition 2 shows that asymmetries in the benefits from exacting revenge make the paradox result more likely. To illustrate the rationale of this result, suppose we start in a fully symmetric situation and then increase the benefit of revenge for one faction and decrease it for the other faction. In the symmetric situation, the value effect and the self-deterrence effect just neutralize each other for both factions. Rendering the factions different then raises the value effect for the faction with high benefit of revenge and reduces the value effect for the faction with low benefit of revenge. The self-deterrence effect changes in the other direction. It becomes stronger for the low-benefit faction and weaker for the high-benefit faction. Overall, the low-benefit faction will therefore reduce its effort, while the high-benefit faction will increase it. But the change in the low-benefit faction's effort dominates that in the high-benefit faction's effort, so aggregate effort falls and we obtain the paradox of revenge.[13]

Finally, we consider asymmetries in the factions' valuations of the resource. To abstract from the mechanism already identified in Propositions 1 and 2, suppose a common linear revenge benefit $R_j(x_{k1}) = R(x_{k1}) = x_{k1}$. Furthermore, we still focus on the case $\eta = 1$. But the resource valuations, V_j and V_k, are now different. We then obtain

Proposition 3: Suppose $\eta = 1$, $V_j \neq V_k$ and $R_j(x_{k1}) = R(x_{k1}) = x_{k1}$. Then $\hat{X} < \tilde{X}$.

Proof: Equations (13) and (15) reduce to

$$\hat{X}_2 = \frac{\hat{x}_{j1}\hat{x}_{k1}}{\hat{x}_{k1} + \hat{x}_{j1}}, \frac{d\hat{\pi}_{j2}}{dx_{j1}} = -\frac{2\hat{x}_{k1}^3}{(\hat{x}_{k1} + \hat{x}_{j1})^3}.$$

Inserting the second expression into equation (17) and rearranging gives

$$\hat{x}_{j1} = \frac{\hat{x}_{j1}\hat{x}_{k1}V_j}{(\hat{x}_{j1} + \hat{x}_{k1})^2} - \frac{2\hat{x}_{j1}\hat{x}_{k1}^3}{(\hat{x}_{k1} + \hat{x}_{j1})^3},$$

$$\hat{x}_{k1} = \frac{\hat{x}_{j1}\hat{x}_{k1}V_k}{(\hat{x}_{j1} + \hat{x}_{k1})^2} - \frac{2\hat{x}_{k1}\hat{x}_{j1}^3}{(\hat{x}_{k1} + \hat{x}_{j1})^3}$$

.

Aggregate effort in the presence of revenge therefore amounts to

$$\hat{X} = \hat{x}_{j1} + \hat{x}_{k1} + \hat{X}_2 = \frac{\hat{x}_{j1}\hat{x}_{k1}(V_j + V_k)}{(\hat{x}_{j1} + \hat{x}_{k1})^2} - \frac{\hat{x}_{j1}\hat{x}_{k1}(\hat{x}_{k1} - \hat{x}_{j1})^2}{(\hat{x}_{k1} + \hat{x}_{j1})^3}.$$

From equation (10), we obtain aggregate effort in the absence of revenge as

$$\tilde{X} = \frac{V_j V_k}{V_j + V_k}.$$

Hence, $\hat{X} < \tilde{X}$ if and only if

$$\frac{(\hat{x}_{j1}V_j - \hat{x}_{k1}V_k)(\hat{x}_{k1}V_j - \hat{x}_{j1}V_k)}{V_j + V_k} - \frac{\hat{x}_{j1}\hat{x}_{k1}(\hat{x}_{k1} - \hat{x}_{j1})^2}{\hat{x}_{k1} + \hat{x}_{j1}} < 0. \qquad 18$$

Without loss of generality, suppose $V_j > V_k$. From the above implicit solutions for $\hat{x}_{j1}$ and $\hat{x}_{k1}$ it is straightforward to show

$$\hat{x}_{j1} - \hat{x}_{k1} = \frac{\hat{x}_{j1}\hat{x}_{k1}(V_j - V_k)}{\hat{x}_{j1}^2 + \hat{x}_{k1}^2}.$$

Moreover, from the implicit solutions we also obtain

$$\hat{x}_{k1}V_j - \hat{x}_{j1}V_k = \frac{2(\hat{x}_{k1}^3 - \hat{x}_{j1}^3)}{\hat{x}_{j1} + \hat{x}_{k1}}.$$

Hence, $V_j > V_k$ implies $\hat{x}_{j1} > \hat{x}_{k1}$, $\hat{x}_{j1}V_j > \hat{x}_{k1}V_k$, and $\hat{x}_{k1}V_j < \hat{x}_{j1}V_k$, so equation (18) is satisfied and we obtain $\hat{X} < \tilde{X}$. (Q.E.D.)

According to Proposition 3, asymmetries in the valuation of the resource also make the paradox of revenge more likely. To understand the rationale of this insight, suppose again we start in the fully symmetric situation and then increase the valuation of one faction and decrease the valuation of the other faction. In the symmetric situation, the value effect and the deterrence effect just neutralize each other for both factions. Increasing the valuation of one faction then ceteris paribus gives this high-valuation faction the incentive to raise first period effort. This makes both the value effect of the low-valuation faction and the self-deterrence effect of the high-valuation faction stronger. By the same argument, reducing the valuation of the low-valuation faction lowers both the value effect of the high-valuation faction and the self-deterrence effect of the low-valuation faction. Overall, the low-valuation faction increases its total effort, while the high-valuation faction reduces it. Since the latter effect dominates, we obtain the paradox of revenge.

Discussion of Assumptions and Results

Arguably, our model omits several aspects of revenge in real world conflicts. For example, our framework implicitly assumes that a faction obtains a benefit from revenge only if it is successful in the conflict. In real-world conflicts, a benefit from revenge may also accrue to the loser of the conflict. But this effect can easily be integrated in our model without changing the main insights. To see this, assume that faction j's benefit of revenge is $R_j(x_{k1})$ if it wins the conflict in period 2 and $\gamma R_j(x_{k1})$ with $\gamma < 1$ if it loses the conflict in period 2. The latter event occurs with probability $1 - P_{j2}$. The condition $\gamma < 1$ means that the value of revenge is lower if the faction loses the conflict than if it wins the conflicts, which seems to be a plausible assumption. This formulation does not change the result that a faction's equilibrium payoff in period 2 is increasing in its opponent's period 1 effort or is decreasing in its own period 1 effort (i.e., the self-deterrence effect). Furthermore, one may also argue that our model ignores the fact that destruction by one faction imposes a direct cost on the other faction. Such a direct cost may be incorporated in our analysis by subtracting from the benefit of faction j the term βx_{jt} in period t with $\beta > 0$. However, while these extensions will alter the details of the analysis, they will not change our main insight that the desire for revenge could lead to a reduction in aggregate efforts in the conflict by causing a self-deterrence effect.

One may object to the way we have modeled revenge on the grounds that it is tantamount to arguing that the factions in our conflict have masochistic preferences in the sense that they derive satisfaction from being hurt. This is a tricky issue which is akin to the problem of doing welfare economics in behavioral economics. Neither faction derives satisfaction from suffering destruction. Such destruction is clearly a cost to them. However, given that destruction has been suffered in the past, the victim derives satisfaction from exacting revenge. Having a preference for revenge is like having intransitive or time-inconsistent preferences where an action which was a cost in period t becomes a benefit in period $t + 1$. Arguably, there are other ways of doing welfare economics when agents have intransitive preferences, although a general consensus is yet to emerge on this issue (see, e.g., Carmichael and MacLeod 2006; Bernheim and Rangel 2007, 2009).

Our paradox of revenge result can be given an evolutionary interpretation in the sense that revenge may have evolved because it enhances evolutionary fitness and therefore evolved equilibria will be those in which our paradox holds. This point is consistent with Frank (1988). To be sure, revenge, being a commitment device, can improve a player's payoff (Schelling 1960; Crawford 1982).[14] To see this, suppose faction 1 has a desire to exact revenge but faction 2 does not have such a desire. Then faction 1 is not subject to a self-deterrence effect since faction 2 has *no* desire to exact revenge. So, all things being equal, faction 1 will increase its effort relative to the no-revenge case. In contrast, faction 2 is subject to a deterrence effect but has no desire for revenge. So, all things being equal, faction 2 will decrease its effort relative to the no-revenge case. Then using each faction's *material* payoff to represent his *evolutionary fitness*,[15] intuitively it holds that faction 1 has a higher material payoff than faction 2.

Historical narratives of the atrocities of one group against another, while useful as a way of understanding the past, may also have the undesirable effect of increasing the cost of conflict because they increase the benefit of exacting revenge (i.e., α) or make the benefit of revenge too sensitive to atrocities suffered (i.e., elastic). This is especially true between groups with a history of conflict such as the Israelis and Palestinians, the Serbs and Croats, and the Hutus and Tutsis. Such stories may be distorted in order to promote hatred toward one's opponents. Glaeser (2005) presents a nonconflict model of such "entrepreneurs of hate" or hate-mongering. He argues that policies intended to promote integration including intermarriages will tend to make such stories ineffective since these forms of interaction make it easier to verify the truth. However, there is no incomplete information in our model, so stories about past atrocities need not be distorted. However, their continual repetition across generations with the goal of promoting hatred is enough to maintain or increase the utility from exacting revenge or decrease the rate at which past destruction is forgotten. In contrast, reconstruction assistance such as those given to Lebanon after the 1975–1990 war may help in increasing the rate at which past destruction is forgotten, although memories of the destruction of human lives is unlikely to be affected by such reconstruction assistance.

In repeated games, it is well known that socially desirable or cooperative outcomes can be sustained by using punishments such as trigger (grim) strategies. However, some of these forms of punishment that support cooperation are not immune to renegotiation and so are not credible. Following Farrell and Maskin (1989) and Bernheim and Ray (1989), there is now a literature that focuses on renegotiation-proof equilibria in repeated games. Renegotiation-proofness is an equilibrium refinement that usually narrows the set of subgame-perfect equilibria in a dynamic game. It is interesting to note that since revenge is part of a player's preferences (i.e., he or she derives utility from exacting revenge), it is a credible threat and so punishing one's opponent is not a Pareto-dominated action. It follows that our paradox of revenge result is not only socially desirable but also renegotiation proof. A revenge-induced equilibrium is not robust to renegotiation only if the preferences of the players can be changed. It may well be that if mediators appeal to the conscience of warring factions and encourage them to lay down their arms, they may be trying to moderate their desire for revenge, so that the players would look to the future instead of the past.

Finally, one might want to know the implication of the desire of revenge for the bargaining between the factions. Since revenge adds an additional benefit of success to the factions, it means that in the presence of revenge bigger transfers are required to compensate a faction in bargaining. This is because you have to compensate a faction for two reasons: (1) to give up whatever concessions it may demand (e.g., part of piece of land) and (2) to dissuade it from exacting revenge in order to obtain the benefit thereof. This is likely to imply that the probability of a breakdown in bargaining (no agreement) is higher in the presence of revenge. Anticipating that it is harder to compensate someone who has a desire of revenge may reinforce our paradox result because it means that a faction may try to minimize its opponent's benefit for revenge in order to increase the chances of reaching an agreement in bargaining.[16]

Conclusion

In this article, we have investigated the implications of the desire for revenge for the dynamics of conflicts. We modeled revenge as a prize-enhancing phenomenon where the utility from exacting revenge is increasing in the stock of past destruction. Surprisingly, it turned out that revenge, understood in this sense, need not destabilize the conflict, but on the contrary may itself be a reason why the social cost of conflict may be lowered.

Given that the factions in our model derive satisfaction from exacting revenge, there is no guarantee that the effect of the fear of retaliation (i.e., self-deterrence effect) will be strong enough to outweigh the benefit of exacting revenge (i.e., value effect) resulting in a lower level of destruction relative to the case without revenge. We have constructed examples to show that this is possible. In doing so, we showed that the nature of the benefit of revenge and asymmetries between the factions matter.

We hope that our work has shed some light on our understanding of the effect of revenge on the dynamics of conflict and will lead to further work in this area. For example, an interesting but very challenging extension is to explain why some groups may be more revenge-driven than others? How should welfare economics be undertaken for parties who have a desire for exacting revenge? Should a third party's intervention decision be different when warring factions have a desire to seek revenge relative to when they do not have such a desire? We leave the analysis of such questions for future research.

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Notes

1. Hume (1898, appendix II) notes that "[W]ho see not that vengeance, from the force alone of passion, may be so eagerly pursued as to make us knowingly neglect every consideration of ease, interest, and safety and, like some vindictive animals, infuse our very souls into the wounds we give an enemy."
2. See Rice (1982) for an account of the Hatfield-McCoy's almost forty-year feud.
3. Commenting on the attractiveness of tit-for-tat, Axelrod (1984, 54) observed that "[W]hat accounts for tit-for-tat robust success is its combination of being nice, retaliatory, forgiving, and clear. Its niceness prevents it from getting into unnecessary trouble.

Its retaliation discourages the other side from persisting whenever defection is tried. Its forgiveness helps restore mutual cooperation. And its clarity makes it intelligible to the other player, thereby eliciting long-term co-operation." For a critique of this far-reaching claim, see Martinez-Coll and Hirshleifer (1991) and Binmore (1998).

4. As we argue in our concluding remarks, our revenge equilibrium is renegotiation-proof.
5. The official government Web page of South Africa's Truth and Reconciliation Commission is www.doj.gov.za/trc/. The report of the commission is available at www.info.gov.za/otherdocs/2003/trc/.
6. See the examples in McAfee, Mialon, and Mialon (2010) and the references therein.
7. Jaeger and Paserman (2008) undertake an empirical analysis of response to violence in the Israeli-Palestinian conflict. Unlike economists, the role of revenge in wars, conflicts, and social relationships has been studied by philosophers, legal scholars, political scientists, and psychologists. Examples are the works of Chagnon (1988), Elster (1990), Stuckless and Goranson (1992), Kim and Smith (1993), Suny (1993), Bloom (2001), Juah (2002), Knutson (2004), and Orth (2004).
8. This is the simplest time structure in which we can make our point. It may be argued that there should be a further fight over the resource itself in period 2. In an earlier version of this article, we showed within a full dynamic infinite horizon differential game framework that the paradox result may also occur when in each time period the factions fight for both the resource and the benefit from exacting revenge. See Amegashie and Runkel (2008). The advantage of our simple two-period framework is that we can give the model much more structure and thereby gain more analytical insights on the determinants of the paradox results. The differential game approach, in contrast, is restricted to numerical simulations.
9. It is important to note that the positive value of revenge does not reflect masochistic preferences. A faction does not derive satisfaction from suffering destruction. Destruction is costly to the victim. However, given that destruction has been suffered in the past, the victim derives satisfaction from exacting revenge.
10. These results coincide with those derived by Nti (1999), who was the first to investigate the asymmetric contest model of the type considered here, but within a one-period framework without revenge.
11. Remember that this second-order condition is obtained by changing the time index from 1 to 2 and replacing V_j by R_j in equation (8). Using the equilibrium solution (12) in the resulting expression proves our statement.
12. We suppose an interior solution to the factions' maximization problems and, thus, an interior equilibrium. This requires that the second-order conditions are satisfied and that the payoffs of the factions in the equilibrium are nonnegative. While the complexity of the model does not allow a general proof, for each case considered in the following we are able to construct examples where these conditions are really satisfied. Moreover, numerical simulations show that the examples are not pathological. Details on the computations can be obtained upon request. Put differently, to ensure an interior equilibrium the set of parameter constellations has to be restricted, but the restricted set is not empty.
13. The result obtained in Proposition 2 is a variant of the property inherent in many asymmetric contest models according to which a more unequal playing field reduces aggregate

effort spent in the contest (e.g., Nti 1999). Note, however, that previous studies did not take into account the desire for revenge and, thus, the story of their results is not based on the value and self-deterrence effect, in contrast to our story.

14. The idea that emotion-based punishment is credible and can improve welfare has been experimentally confirmed by Fehr and Gaechter (2000).
15. Using material payoffs implies that we ignore the benefit from exacting revenge and only include the cost of effort and the expected benefit of obtaining the material benefit $V > 0$ in a player's payoff. That the fitness function need not be the same as the players' payoffs in the game is a standard approach in the *indirect evolutionary* approach pioneered by Gueth and Yaari (1992). In the indirect evolutionary approach, evolutionary forces do not directly work on actions as in Smith (1974) but on preferences. Hence, for a given preference, the equilibrium concept is Nash equilibrium and not Evolutionarily Stable Strategies (ESS). See also Gueth and Napel (2006), Ely and Yilankaya (2001), and Dekel, Ely, and Yilankaya (2007) for applications of the indirect evolutionary approach.
16. A thorough analysis of this point will require a formal two-period model of conflict with revenge where the parties have the option of bargaining in period 2 before conflict takes place. To take into account the breakdown in bargaining will require a model of incomplete information. If one does not want to do that, then instead our paradox result will hold not because of a breakdown in bargaining since with complete information, we can find an equilibrium with immediate agreement but instead a faction will reduce its effort in period 1 in order to reduce its opponent's disagreement payoff in the bargaining game and hence increase its payoff in the second period bargaining game.

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