Violence Against Women, Social Learning, and Deterrence

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December 20, 2005

Abstract

We develop a simple model of sexual and domestic violence. By assumption, the potential victim's threat to report if she is victimized is not credible, which implies that the only sequential equilibrium involves violence. However, a realistic social learning process converges to a non-sequential equilibrium without violence from all nearby states if the expected punishment for offenders whose victims report to the police is sufficiently high. A policy to increase the sentences for sexual and domestic violence convictions could therefore substantially reduce such violence in the long run, even if it is powerless to make women's threats to report credible.

JEL Code: K42

Keywords: Violence, Learning, Deterrence

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1. Introduction

From the National Violence Against Women Survey, Tjaden and Thoennes (2000) estimate that 17.6 percent of U.S. women have been raped at some time in their life, that 7.7 percent have been raped by an intimate partner (defined as a current or former husband, cohabitating partner, boyfriend, or date), and that 22.1 percent have been physically assaulted by an intimate partner.[2]

The National Center for Injury Prevention and Control (2003) conservatively estimates the costs of intimate partner violence at around $5.8 billion dollars a year, nearly $4 billion of which is for direct medical and mental health care services. The total annual costs also include $0.9 billion in lost productivity from paid work and household chores and $0.9 billion in lost earnings from intimate partner violence that results in homicide.

To identify a policy that might reduce sexual and domestic violence against women, we propose a simple model of the interaction that often arises between potential offenders and victims in such cases. In the model, the potential offender decides whether to be violent, and the potential victim then decides whether to be silent if she is victimized. Their choices affect each other's payoffs. For example, a potential offender may prefer to be violent only if his potential victim would not report to the police, especially if he is intimately related to her, so that the police could easily apprehend him if she did report.

The potential victim attempts to sustain an equilibrium outcome in which she is not victimized by threatening to break her silence if she is victimized. This threat, however, is assumed not to be credible. In reality, domestic violence victims may not be able to support themselves or their children if their abusive spouses are sent to prison. They may also believe that their children need a father, even if the father is violent.

[2] Physical assault was defined to include a range of violent behaviors, from slapping and hitting to using a gun. Rape was defined as forced intercourse that was completed or attempted.

Moreover, rape and domestic violence victims often strongly prefer to keep others from knowing their situations, as this would cause them shame and humiliation in front of the community. And if they report to the police, their cases may proceed to trial, where intimate details of their personal lives may be further publicized. For these reasons, the potential victim's threat to break her silence if she is victimized is not credible, which leads a sequentially rational potential offender to carry through with his violence, no matter how severe his punishment would be if his victim did break her silence. Thus violence occurs in the only sequentially rational equilibrium.

However, even if the victim's threat to report is not credible, there is a set of equilibria that are not sequentially rational, in which the potential victim avoids violence. We assume that behavior in the model evolves according to social learning dynamics, whereby boys tend to become violent if the men around them are violent and get away with it, and girls tend to be silent given victimization if the women around them are victimized and remain silent. However, boys and girls still randomly drift out of their social circles with a vanishingly small probability.

Social learning forces can lead to an equilibrium that is not sequentially rational if the offender's punishment if his victim breaks her silence is sufficiently high. Increasing the punishment enlarges the set of equilibria that are not sequentially rational, making it more likely that social learning forces settle down near one of its elements, in which case violence does not occur. This is true even though a more severe punishment does not alter the fact that reporting is not optimal for the victim, so that the only sequentially rational equilibrium is still violence and silence. A policy to increase the sentences for sexual or domestic violence convictions could therefore substantially reduce such violence in the long run, even though victims do not have sufficient incentives to report their abusive intimates to the police.

2. Related Literature

Our paper is connected to the relatively small economics literature that attempts to explain domestic violence. Most of this literature formalizes the strategic dimensions of domestic violence with fully rational, non-cooperative, game-theoretic models. This approach yields a number of interesting implications. Tauchen et al. (1991) find that the extent of violence depends on each spouse's income level and whether the wife's reservation utility constraint is binding. Farmer and Tiefenthaler (1996) find that the extent of violence in intact families decreases in the wife's income, as it raises the value of her outside option. Farmer and Tiefenthaler (1997) find that women might rationally use social services, such as shelters and counselling, as signals to misrepresent their outside options. In this way, services can reduce violence even if they are powerless to prevent women from ultimately returning to their abusive relationships.

But decisions related to domestic violence are not easily viewed as purely rational. Pollak (2004) formalizes the evolutionary dimensions of the problem with an intergenerational learning model that assumes that men are more likely to be violent, and women are more likely to remain in a violent relationship, if they grew up in violent families. One interesting implication of the model is that violence increases with the extent to which individuals who grew up in violent homes tend to marry others who grew up in violent homes.

However, the author's model does not take into account that men and women's learning processes are interdependent. The probability that a man is violent is assumed to only depend on whether he grew up in a violent family, not on whether the woman with whom he is matched grew up in a violent family so that she is more likely to remain in a violent relationship. Similarly, the probability that a woman remains in a violent relationship depends only on whether she grew up in a violent family, not on whether the man with whom she is matched grew up in a violent family so that he is more likely to be violent.

The existing literature has focused either exclusively on strategic interaction or exclusively on intergenerational learning, when reality dictates that both are essential elements of the problem. We propose a simple model of sexual and domestic violence that combines both elements. Our model is an application of recent developments in evolutionary game theory. Samuelson (1998) and Fudenberg and Levine (1999) provide comprehensive summaries. The theory of evolutionary games, because it analyzes evolution and social learning in situations of strategic interaction, is ideally suited for the study of sexual and domestic violence.

3. Strategic Interaction

Three main decision-makers are involved in a situation of sexual or domestic violence: the potential offender, the potential victim, and the court. The potential offender decides whether or not to be violent. If the potential offender chooses to be violent, the victim then decides whether or not to be silent.[3] If the victim is not silent, the court then decides whether or not to convict the offender. On the other hand, if the potential offender chooses not to be violent, then nothing further happens.[4]

Let b denote the potential offender's benefit from violence. Let c denote the victim's cost of bearing violence. Let h denote the victim's cost of not being silent. Let r denote the victim's benefit from the incarceration of her offender. Let s denote the penalty imposed by the court if the offender is convicted.

[3] Not being silence is understood to mean reporting to the police and pursuing conviction until a final verdict by the court.

[4] By assuming that nothing happens if the potential offender is not violent, we are ignoring the threat of wrongful accusation. This assumption considerably simplifies the analysis of the social learning dynamics, but it is also consistent with the assumption, which we formally state later, that the potential victim's threat to break her silence if she is victimized is not credible. We will argue that it is not credible in part because the American legal system is strongly biased in favor of defendents, which tends to minimize the threat of wrongful accusation.

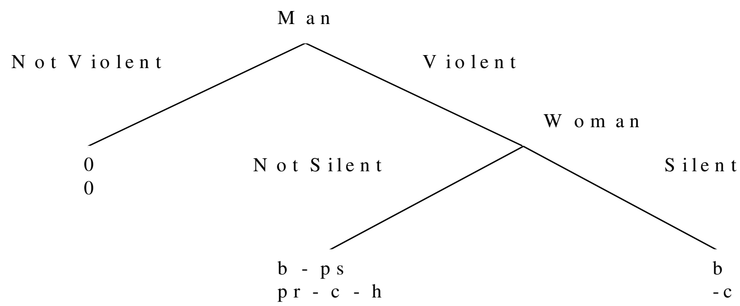

Figure 1: The Intimate Violence Situation, Extensive Form.

If the potential offender is not violent, then both the potential offender and potential victim receive reservation utilities of zero. The court is exogenous and let p denote the probability of a guilty verdict if the victim is not silent. The extensive form of the strategic situation is given in Figure 1. The man's (woman's) utilities over the various outcomes are the first (second) elements in the vectors attached to each terminal node.

Working backwards, we find that if the man is violent, the victim is not silent if and only if $pr > h$. Then if the victim is not silent, the potential offender is violent if and only if $b > ps$. If the victim is silent, the potential offender is violent if and only if $b > 0$. We assume that $0 < b < ps$, that is, the potential offender prefers to be violent if the victim is silent, and prefers not to be violent if the victim is not silent.

The parameter h is particularly high in most sexual and domestic violence cases. Rape and domestic violence are private and humiliating crimes. Victims usually suffer intense shame if their situations become public. They may have to face a lack of understanding, or even negative responses, from family, friends, police, and ministers, especially in a male-dominated society. Moreover, if they report to the police and their cases proceed to trial, they may have to endure a humiliating inquiry into the details of their personal lives. In rape cases, the inquiry may be particularly humiliating as it may delve systematically into their prior sexual history.

Moreover, r is usually low in domestic violence cases. Victims of domestic violence may loose their family's primary source of income if their spouse is incarcerated. Hence, it is likely that $pr < h$ in most sexual and domestic violence cases. But then the unique sequential equilibrium is (Violent, Silent).[5] This outcome is socially harmful for at least two reasons. First, women must suffer the direct costs of the violence, and they do not report it to the police, so the violence is free to continue. Second, the violence creates negative externalities on the immediate families of the victims, as well as on society more broadly, through their lost productivity and the increased medical expenses required to treat them.[6]

One solution is to implement strong social and legal policies to directly alter the situation so that the efficient outcome becomes sequentially rational. For example, policy-makers could increase funding for battered women's shelters and rape counselling services to encourage women to speak out against intimate violence. They could also enact rape shield laws that prohibit defendants from using the victim's prior sexual history or dress habits as evidence at trial. These policies could potentially lower h, and increase r. If they could do so sufficiently that $pr > h$, then the only sequentially rational equilibrium of the strategic situation in Figure 1 becomes (Not Violent, Not Silent). If the offender's benefit from violence b is not larger than the sum of the victim's cost of being victimized c and the negative externalities of violence mentioned above, then this is the socially efficient outcome.

However, battered women's shelters and counselling services are not sufficiently funded to make most women credible in their threats to break their silence, especially if they depend on their spouses for income to support themselves and their children.[7] And although rape

[5] Sequential rationality requires that the woman choose her strategy optimally given victimization.
[6] Moreover, if the violence is witnessed by the children of the victims, then it may be transmitted to the next generation, along with its negative externalities. We discuss intergenerational learning in the next section.
[7] This is a source of continued frustration for shelter counsellors. Despite their best efforts to encourage rape and domestic violence victims to leave their abusive relationships and press charges, many victims return

Table 1: The Intimate Violence Situation, Normal Form

	Silent	Not Silent
Violent	$b, -c$	$b - ps, pr - c - h$
Not Violent	0, 0	0, 0

shield laws were enacted by most of the United States in the late 1970s under pressure from the feminist movement, these laws are consistently ignored in practice and rape victims find themselves defending their past and their dress habits anyway (Bachman and Paternoster, 1993, Taslitz, 1999), especially when the alleged offender is an acquaintance. Rape shield laws directly conflict with a defendant's Sixth Amendment right to "be confronted with the witnesses against him" (see Tanford and Bocchino, 1980). The American legal system is heavily biased in favor of defendants. Thus we assume that policy-makers cannot alter the situation so that $pr > h$.[8]

However, even if $pr < h$, the strategic situation in Figure 1 has many Nash equilibria that are not sequentially rational. The normal form of the strategic situation is given in Table 1. Let α denote the probability that a potential offender is not violent, and β denote the probability that a potential victim is not silent if she is victimized. If the man is not violent, $\alpha = 1$, the woman is indifferent between silence and prosecuting given violence, so any prosecution probability $\beta \in [0, 1]$ is a best response. On the other hand, $\alpha = 1$ is a best response only if β is high enough that the man's expected utility of violence is lower than that of non-violence. This happens when $\beta > \frac{b}{ps}$. Therefore the strategic situation has a component of equilibria that are not sequentially rational, in which the potential offender is not violent and the potential victim would not be silent with probability greater than $\frac{b}{ps}$.[9]

and remain silent (Farmer and Tiefenthaler, 1996).

[8] This assumption is consistent with our assumption that nothing happens if the woman is not victimized, so that there is no chance of a wrongful conviction. The American legal system favors defendents to minimize wrongful convictions.

[9] These equilibria are not sequentially rational because the woman is not choosing her optimal strategy given victimization. Given the parameter assumptions, silence is her optimal strategy if she is victimized.

The larger is the punishment, ps, that a man can expect if he is violent and is prosecuted by his victim, the smaller the prosecution probability β has to be for him not to be violent, that is, for $\alpha = 1$ to be a best response. Therefore, if the probability of conviction, p, or the sentence length, s, for sexual or domestic violence were to increase, the component of Nash equilibria that are not sequentially rational would grow. The outcome is identical in each of these equilibria, and is the socially efficient one: no violence. But what might lead potential offenders and their potential victims toward the efficient outcome that is not sequentially rational?

4. Social Learning

Sexual or domestic violence is not easily viewed as a purely rational or strategic choice. On the other hand, considerable evidence has been tallied in support of intergenerational learning theories of sexual and domestic violence. Rape prone men tend to come from harsh developmental backgrounds in which social relationships were conducted with manipulation, coercion, and violence (Malamuth and Heilman, 1998). Analyzing data from an extensive survey of American families by Straus and Gilles (1990), Kalmuss (1994) finds that observing hitting between one's parents substantially increases the probability that one will be involved in marital aggression as an adult, either as a victim or a perpetrator.

Consider the following model of intergenerational and social learning, inspired from Bjornersted and Weibull (1995) and Fudenberg and Levine (1999), and applied to the strategic situation in Table 1. Each period, a fraction of men leaves the system. The men who leave the system are replaced by their sons. Each son learns the strategy of his father and of another male randomly sampled from the same population, but only observes a noisy signal of the sampled payoff. If the observed payoff of the sampled strategy is higher than the payoff of the inherited strategy, and the difference cannot be attributed only to noise, then the sons switch to their sampled strategy; otherwise, they continue to follow their inherited strategy.

Let $\alpha(t)$ be the proportion of men who are not violent at time t, and let $\beta(t)$ be the proportion of women who would not be silent if they were victimized at time t. Sons who inherited a strategy with payoff u_1 observe the payoff u_1, and sons who sampled a strategy with payoff u_2 observe a payoff $u_2 + \varepsilon$. We assume that ε is uniformly distributed on a sufficiently large interval, so that the cumulative density function of the difference between any two noise terms can be written as $F(u) = a + ku$, $k > 0$.[10] Sons who sample a male using the same strategy as their father do not switch. At date t, a fraction $\alpha(t)^2$ of the sons have a non-violent father and have sampled another non-violent male. These sons will continue to be non-violent. And a fraction $(1 - \alpha(t))^2$ of sons have a violent father and have sampled another violent male. These sons will continue to be violent. Sons who have a non-violent father, but who sampled a violent male, are violent with probability

$$\begin{aligned} P\{\varepsilon &< u[\text{Violent}, \beta(t)] - u[\text{Not Violent}, \beta(t)]\} \\ &= a + k\{u[\text{Violent}, \beta(t)] - u[\text{Not Violent}, \beta(t)]\} \end{aligned} \tag{1}$$

where $k > 0$. Sons who have a violent father, but who sampled a non-violent male, are non-violent with probability $a + k\{u[\text{Not Violent}, \beta(t)] - u[\text{Violent}, \beta(t)]\}$. Therefore, male behavior evolves according to the following social learning dynamic

$$\begin{aligned} \dot{\alpha}(t) &= \alpha(t)(1 - \alpha(t))\{a + k\{u[\text{Not Violent}, \beta(t)] - u[\text{Violent}, \beta(t)]\}\} \\ &\quad -\alpha(t)(1 - \alpha(t))\{a + k\{u[\text{Violent}, \beta(t)] - u[\text{Not Violent}, \beta(t)]\}\} \end{aligned} \tag{2}$$

[10] It is reasonable to assume that sons receive a noisy signal about the payoff of the strategy they sample. For example, a son who finds out that a neighbor is violent with his wife may only have imperfect information about whether the neighbor got away with the crime, or how much jail time he served for it.

After some algebra, we obtain

$$\dot{\alpha}(t) = 2k\alpha(t)\{u[\text{Not Violent}, \beta(t)] - \overline{u}\} \tag{3}$$

where $\overline{u} = \alpha(t)u[\text{Not Violent}, \beta(t)] + [1 - \alpha(t)]u[\text{Violent}, \beta(t)]$ is the average payoff of the male population in period t.[11]

The story is similar for the population of women. Each period, some women are replaced by their daughters, who know their mother's strategy and the strategy of another female randomly sampled from the population. Daughters switch away from their inherited strategy only if the sampled strategy dominates by a greater extent that can be attributed to noise. This yields an analogous social learning dynamic for daughters:

$$\dot{\beta}(t) = 2k\beta(t)\{v[\text{Not Silent}, \alpha(t)] - \overline{v}\} \tag{4}$$

where $\overline{v} = \beta(t)v[\text{Not Silent}, \alpha(t)] + [1 - \beta(t)]v[\text{Silent}, \alpha(t)]$ is the average payoff of the female population in period t.

From Table 1, we find that

$$u[\text{Not Violent}, \beta(t)] = 0,\ \overline{u}[\beta(t)] = [1 - \alpha(t)][b - \beta(t)ps] \tag{5}$$

$$v[\text{Not Silent}, \alpha(t)] = [1 - \alpha(t)][pr - h - c],\ \overline{v}[\alpha(t)] = [1 - \alpha(t)]\{-\mathbf{c} - \beta(t)[h - pr]\} \tag{6}$$

Substituting these expressions into (3) and (4) and simplifying yields:

$$\dot{\alpha} = 2k\alpha(1 - \alpha)(\beta ps - b) \tag{7}$$

$$\dot{\beta} = 2k\beta(1 - \beta)(\alpha - 1)(h - pr) \tag{8}$$

This model of social learning may describe actual social learning to a good approximation, but it is too simple to capture all the imperfections of the real-world. For reasons not

[11]Equation (3) is a time rescaling of the "replicator dynamic," introduced by Taylor and Jonker (1978) and Schuster and Sigmund (1983) to describe evolution from a biological perspective.

captured by the model, boys and girls may on rare occasion break out of their social circles. For example, a few sons may unexpectedly be violent even though their social environment is completely non-violent. Similarly, a few daughters may unexpectedly break a vicious cycle of silence.

One way to conceptualize this reality is to introduce random drift in the social learning system. Binmore et al. (1995), Samuelson (1998), and Binmore and Samuelson (1999) formalize drift, and analyze its implications, in important evolutionary models. We apply elements of their analysis to the above social learning system for intimate partner violence.

Adding random drift to (7)-(8), we obtain

$$\dot{\alpha} = 2k(1-\delta_m)\alpha(1-\alpha)(\beta ps - b) + \delta_m(\frac{1}{2} - \alpha) \quad (9)$$

$$\dot{\beta} = 2k(1-\delta_w)\beta(1-\beta)(\alpha - 1)(h - pr) + \delta_w(\frac{1}{2} - \beta) \quad (10)$$

where δ_m and δ_w are the drift rates for the populations of men and women, respectively. With probabilities δ_m and δ_w, men and women drift away from their respective social learning paths, and instead follow one of their two strategies at random (each with $\frac{1}{2}$ probability). The drift rates are assumed to be arbitrarily small. They introduce a weak tendency to move away from extremes. For example, if most women are not silent, because most men are not violent, then drift creates a faint counter-pressure in favor of silence; and if most men are not violent, because most women are not silent, then drift creates a faint counter-pressure in favor of violence.[12]

The following proposition identifies the asymptotically stable states of the social learning system with random drift, (9)-(10).[13]

[12] The role of random drift in biological evolution is now widely recognized. It is consistent with findings of molecular variation in DNA that has no influence on genetic fitness, i.e., that is selectively neutral (see Kimura, 1983).

[13] An equilibrium is an asymptotically stable state of a dynamic system if the system's trajectories converge to the equilibrium from all nearby states.

Proposition 1 *Let* $\psi = \frac{\delta_m(1-\delta_w)}{\delta_w(1-\delta_m)} > 0$*.*

1. *If* $\frac{b}{ps} > \frac{1}{2}$*, or* $\frac{b}{ps} < \frac{1}{2}$ *and* $\psi > \frac{ps-2\sqrt{b(ps-b)}}{h-pr} > 0$*, the only asymptotically stable state of the social learning system is the sequentially rational equilibrium* $(\alpha, \beta) = (0, 0)$*.*

2. *If* $\frac{b}{ps} < \frac{1}{2}$ *and* $0 < \psi < \frac{ps-2\sqrt{b(ps-b)}}{h-pr}$*, the social learning system has two asymptotically stable states, the sequentially rational equilibrium* $(0, 0)$ *and an equilibrium that is not sequentially rational* $(1, \beta^*)$*, where* $\beta^* = \frac{(ps+2b)-\psi(h-pr)+\sqrt{((ps+2b)-\psi(h-pr))^2-4b(2ps-\psi(h-pr))}}{2(2ps-\psi(h-pr))}$ *and* $\frac{b}{ps} < \frac{-b+\sqrt{b(ps-b)}}{ps-2b} < \beta^* < \frac{1}{2}$*.*

Proof. Propositions are proved in the Mathematical Appendix. ■

A Nash equilibrium that is not sequentially rational is an asymptotically stable state of the social learning system (9)-(10) if and only if (i) $\frac{b}{ps} < \frac{1}{2}$ and (ii) $\psi < \frac{ps-2\sqrt{b(ps-b)}}{h-pr}$. Condition (i) is more likely to be satisfied the larger is s, men's punishment for being violent if their victim reports and they are convicted. Moreover, if condition (i) is satisfied, then condition (ii) is more likely to be satisfied for any given ψ the larger is s, since $\frac{\partial(ps-2\sqrt{b(ps-b)})}{\partial s} > 0 \Leftrightarrow \frac{b}{ps} < \frac{1}{2}$, which must hold by condition (i). Therefore, the larger is s, the more likely conditions (i) and (ii) are jointly satisfied, and hence the more likely the social learning system converges asymptotically to a Nash equilibrium that is not sequentially rational.

The intuition is the following. The larger is s, the smaller the prosecution probability β has to be for men not to be violent. Suppose β can be smaller than $\frac{1}{2}$ and men still prefers not to be violent, which happens if s is large enough that condition (i) is satisfied. Then there is a subset of the component of non-sequential Nash equilibria in which $\alpha = 1$ and β is smaller than $\frac{1}{2}$. If social learning is hovering around this subset of the component, drift in the social learning dynamic for women puts pressure to increase β. Because women are more often silent, the drift is in the direction of breaking silence, as its weak pressure is always to move away from extremes. On the other hand, drift in the social learning dynamic for men puts pressure to reduce α. Since most men are non-violent, the drift is in the direction of increasing violence. This slightly reduces women's incentive to break their silence if they are victimized, which indirectly puts pressure to reduce β.

However, the larger is s, the less drift in the dynamic for men reduces α, and hence the less pressure there is to reduce β. Therefore, if s is large enough, then the pressure to increase β coming from drift in the dynamic for women is stronger than the pressure to reduce β coming from the drift in the dynamic for men. In this case, the social learning system does not lead away from the subset of the component of non-sequential Nash equilibria in which $\alpha = 1$ and $\beta \in [\frac{b}{ps}, \frac{1}{2}]$, but rather converges to one of its elements. Hence, there exists an asymptotically stable Nash equilibrium in which $\alpha = 1$ and $\beta \in [\frac{b}{ps}, \frac{1}{2}]$ provided s is large enough. Increasing the punishment for being violent enlarges the component of non-sequential Nash equilibria, and increases the chances that drift stabilizes one of its elements.

Victims of sexual or domestic violence may prefer not to press charges no matter how severe is their offender's punishment, because either the pain and humiliation associated with making the affair public is too great, or the victim and her family cannot survive without the offender's income. Nevertheless, increasing the punishment if they did press charges could ensure that social learning processes remain near a state without sexual or domestic violence in the long run.

The non-sequential Nash equilibrium that is an asymptotically stable state of the social learning system if s is sufficiently large is $\alpha = 1$ and $\beta = \beta^*$, where β^* is given in proposition 1. It is also interesting to know how β^*, women's reporting probability if they are victimized in this equilibrium, varies with s.

Proposition 2 $\frac{\partial \beta^*}{\partial s} > 0$.

The non-sequential equilibrium $\alpha = 1$ and $\beta = \beta^*$ is asymptotically stable if s is sufficiently large, because in this case, the force created by the drift in the dynamic for men, which randomly introduces violence and tends to reduce reporting and lead away from the non-sequential equilibrium, is weaker than the force created by the drift in the dynamic for women, which tends to increase reporting and lead back toward the equilibrium. But if s is increased further, then the force that reduces reporting is even smaller relative to the force that increases reporting, so that the dynamic system converges to a non-sequential equilibrium in which women report with an even higher probability. In this way, an increase in s increases β^*.

This may matter to social welfare. When the system is near the non-sequential equilibrium that is asymptotically stable, drift in the dynamic for men randomly introduces violence. But if the punishment is increased, women's probability of reporting if they are victimized in the non-sequential equilibrium increases, so more of the men who are randomly violent near the equilibrium are reported to the police. Thus, increasing punishment not only increases the chances that drift stabilizes a non-sequential equilibrium without violence, but also increases women's reporting probability in this equilibrium, so when the system is shocked with random violence near the equilibrium, more of the randomly violent men are incapacitated.

5. Policy Implication

Currently, in most countries, including the U.S. and England, expected punishments for reported crimes against intimate victims are significantly lower than those for the same crimes against non-intimates. Wells (2003) analyzes data on 260,000 arrests between 2000 and 2002 in Arizona, where police are required to choose whether to designate a crime as domestic violence at the time of arrest. The author finds that arrests for a crime with a domestic violence designation are less likely to result in conviction, and convictions result in significantly lighter sentences, than arrests and convictions for the same crime without the domestic violence designation. Approximately 40 percent of men in the sample who were arrested for aggravated assault without the designation were sent to prison versus only 23 percent of men who were arrested for the same crime with the designation. Most men convicted of aggravated assault with the designation received a fine or probation.

Gregory and Lees (1999) provide evidence from England that prosecuted sexual assault cases involving acquaintances are most likely to result in acquittal. The Home Office's Sentencing Advisory Panel (2002) reports that sentencing practices in rape cases are more lenient when the victim and offender know each other, despite the fact that the current guidelines, last issued in 1986, do not mention the relationship between victim and offender as a factor that should affect the sentence. In the case of R. v. Berry [10 Cr. App. R. (S.) 13, 1988], the Court's judgment states that "the rape of a former wife or mistress might have exceptional features which make it a less serious offence than otherwise it would be." Following Berry, subsequent rulings have generally treated a relationship between the offender and the victim as an important mitigating factor.

The Sentencing Panel's recommendation to the Court of Appeals is that convicted rapists who know their victims should be given the same sentence as those who does not. The model presented in this paper suggests that a legal policy to treat sexual or aggravated assault on an intimate partner as an offense as serious as sexual or aggravated assault on a stranger could eventually significantly reduce intimate partner violence through its effect on the important social learning forces that underlie the problem. Such a policy may be less costly to implement and ultimately more effective at reducing intimate violence than a policy to encourage victims to report their abusive intimates to the police.

6. Mathematical Appendix

Proof of Proposition 1. Setting $\dot{\alpha} = \dot{\beta} = 0$ and $(\delta_m,\, \delta_w) = (0,\, 0)$ in the social learning system (9)-(10), we obtain

$$\alpha(1-\alpha)(\beta ps - b) = 0 \tag{11}$$

$$\beta(1-\beta)(\alpha - 1)(h - pr) = 0. \tag{12}$$

This yields $(0,0)$, $(0,1)$ and $(1,\beta)$ as candidates for limit points of the social learning system. The first point is a source for the unperturbed social learning system and is easily excluded as a limit point. The second point is the sequentially rational equilibrium and is easily shown to always be an asymptotically stable state of the system, perturbed or unperturbed. We focus on the stability of the third point. To find the value of β in the third point, set $\dot{\alpha} = \dot{\beta} = 0$ in (9)-(10) to obtain

$$\delta_m(2\alpha - 1) = 4k(1-\delta_m)\alpha(1-\alpha)(\beta ps - b) \tag{13}$$

$$\delta_w(2\beta - 1) = 4k(1-\delta_w)\beta(1-\beta)(\alpha - 1)(h - pr). \tag{14}$$

Divide (13) by (14) to obtain

$$\psi = \frac{(2\beta - 1)\alpha(\beta ps - b)}{(1-2\alpha)\beta(1-\beta)(h-pr)}, \tag{15}$$

where $\psi = \frac{\delta_m(1-\delta_w)}{\delta_w(1-\delta_m)}$. Setting $\alpha = 1$ and doing some algebra, we obtain

$$(-\psi(h-pr) + 2ps)\beta^2 + (\psi(h-pr) - ps - 2b)\beta + b = 0. \tag{16}$$

For the solution β to be real, we require that

$$(\psi(h-pr) - ps - b)^2 - 4(-\psi(h-pr) + 2ps)b > 0. \tag{17}$$

This condition is equivalent to

$$(h-pr)^2\psi^2 - 2ps(h-pr)\psi + (ps-2b)^2 > 0. \tag{18}$$

Consider the corresponding quadratic equation

$$(h-pr)^2\psi^2 - 2ps(h-pr)\psi + (ps-2b)^2 = 0. \tag{19}$$

The roots of this equation are

$$\psi_{1,2} = \frac{ps \mp 2\sqrt{b(ps-b)}}{h-pr}. \tag{20}$$

Note that $\psi_2 > \psi_1 > 0$ since

$$\psi_1 > 0 \Leftrightarrow ps > 2\sqrt{b(ps-b)} \Leftrightarrow (ps-2b)^2 > 0. \tag{21}$$

The quadratic expression in (19) is positive when $0 < \psi < \psi_1$, zero when $\psi = \psi_1$ and when $\psi = \psi_2$, and positive when $\psi > \psi_2$. Thus, for the solution β to (16) to be real, it must be that $\psi > \psi_2$ or $0 < \psi < \psi_1$. Now, the roots of the quadratic equation in (16) are

$$\beta_{1,2} = \frac{(ps+2b) - \psi(h-pr) \mp \sqrt{((ps+2b)-\psi(h-pr))^2 - 4b(2ps-\psi(h-pr))}}{2(2ps-\psi(h-pr))}. \tag{22}$$

At $\psi = \psi_1$,

$$\beta_{1,2}|_{\psi=\psi_1} = \beta|_{\psi=\psi_1} = \frac{(ps+2b)-\psi(h-pr)}{2(2ps-\psi(h-pr))} = \frac{-b-\sqrt{b(ps-b)}}{ps-2b}. \tag{23}$$

At $\psi = \psi_2$,

$$\beta_{1,2}|_{\psi=\psi_2} = \beta|_{\psi=\psi_2} = \frac{(ps+2b)-\psi(h-pr)}{2(2ps-\psi(h-pr))} = \frac{-b+\sqrt{b(ps-b)}}{ps-2b}. \tag{24}$$

Note that

$$-b+\sqrt{b(ps-b)} > 0 \Leftrightarrow ps > 2b. \tag{25}$$

Thus if $ps < 2b$, then $\beta|_{\psi=\psi_1} > 0$ and $\beta|_{\psi=\psi_2} > 0$. In this case, there are two solutions β_1 and β_2, such that

$$\frac{1}{2} < \beta_1 < \frac{-b + \sqrt{b(ps-b)}}{ps - 2b} < \beta_2 < \frac{b}{ps}. \tag{26}$$

On the other hand, if $ps > 2b$,then $\beta|_{\psi=\psi_2} > 0$, $\beta|_{\psi=\psi_1} < 0$. For $\psi > \psi_2$,it must be true that

$$\begin{aligned} \psi &= \frac{(2\beta-1)(\beta ps - b)}{(-1)\beta(1-\beta)(h-pr)} > \frac{ps + 2\sqrt{b(ps-b)}}{h - pr} = \psi_2 \\ &\Leftrightarrow \;\; 0 > (ps - 2\sqrt{b(ps-b)})\beta^2 + (2\sqrt{b(ps-b)} - 2b)\beta + b, \end{aligned}$$

which is a contradiction. Therefore, when $ps > 2b$ and $\psi > \psi_2$,there is no solution $\beta \in [0,1]$ to (16).

But when $ps > 2b$ and $\psi < \psi_1$, there are two solutions β_1 and β_2, such that

$$\frac{b}{ps} < \beta_1 < \frac{-b + \sqrt{b(ps-b)}}{ps - 2b} < \beta_2 < \frac{1}{2}. \tag{27}$$

In these cases, the social learning system has limit points at $(1, \beta_1)$ and $(1, \beta_2)$, which are Nash equilibria that are not sequentially rational.

We now show that if $ps > 2b$ and $\psi < \psi_1$, then $(1, \beta_2) = (1, \beta^*)$ is an asymptotically stable state of the social learning system, but if $ps < 2b$, then neither $(1, \beta_1)$ nor $(1, \beta_2)$ are asymptotically stable. The Jacobian of system (9)-(10) is

$$\begin{aligned} &J(\alpha, \beta) \qquad\qquad (28) \\ = &\begin{bmatrix} 2k(1-\delta_m)(1-2\alpha)(\beta ps - b) - \delta_m & 2k(1-\delta_m)\alpha(1-\alpha)ps \\ 2k(1-\delta_w)\beta(1-\beta)(h-pr) & 2k(1-\delta_w)(1-2\beta)(\alpha-1)(h-pr) - \delta_w \end{bmatrix}. \end{aligned}$$

The trace of J is

$$\begin{aligned} Tr(J) &= 2k(1-\delta_m)(1-2\alpha)(\beta ps - b) - \delta_m \\ &\quad +2k(1-\delta_w)(1-2\beta)(\alpha-1)(h-pr) - \delta_w. \end{aligned} \tag{29}$$

Setting $\alpha > \frac{1}{2}$, and δ_m and δ_w close to 0, we see that $Tr(J) > 0$ if $\frac{1}{2} < \beta < \frac{b}{ps}$. Therefore, both $(1, \beta_1)$ and $(1, \beta_2)$ are unstable if $ps < 2b$. But $Tr(J) < 0$ if $\frac{b}{ps} < \beta < \frac{1}{2}$. Therefore, we consider the sign of the limiting value of the determinant of J in this case. We multiply each element of the second column of the determinant of J by $(1-2\beta)$ (this does not affect its sign since $1-2\beta > 0$ in the range that we are considering), to obtain

$$\begin{aligned} &Det(J) \\ &= \begin{vmatrix} 2k(1-\delta_m)(1-2\alpha)(\beta ps - b) - \delta_m & 2k(1-\delta_m)\alpha(1-\alpha)ps(1-2\beta) \\ 2k(1-\delta_w)\beta(1-\beta)(h-pr) & 2k(1-\delta_w)(1-2\beta)^2(\alpha-1)(h-pr) - \delta_w(1-2\beta) \end{vmatrix}. \end{aligned} \tag{30}$$

We know that (14) holds when $\dot{\alpha} = \dot{\beta} = 0$. Replacing $\delta_w(2\beta - 1)$ above with the right hand side of (14), we obtain

$$\begin{aligned} &Det(J) \\ &= \begin{vmatrix} 2k(1-\delta_m)(1-2\alpha)(\beta ps - b) - \delta_m & 2k(1-\delta_m)\alpha(1-\alpha)ps(1-2\beta) \\ 2k(1-\delta_w)\beta(1-\beta)(h-pr) & 2k(1-\delta_w)(1-\alpha)(h-pr)(-2\beta^2+2\beta-1) \end{vmatrix}. \end{aligned} \tag{31}$$

Factoring out common terms, we obtain

$$\begin{aligned} &Det(J) \\ &= 4k^2(1-\delta_m)(1-\delta_w)(1-\alpha)(h-pr) * \begin{vmatrix} (1-2\alpha)(\beta ps - b) - \frac{\delta_m}{1-\delta_m} & \alpha ps(1-2\beta) \\ \beta(1-\beta) & (-2\beta^2+2\beta-1) \end{vmatrix}. \end{aligned} \tag{32}$$

Since $4k^2(1-\delta_m)(1-\delta_w)(1-\alpha)(h-pr) > 0$, the sign of $Det(J)$ is the same as the sign of the determinant

$$\begin{vmatrix} (1-2\alpha)(\beta ps - b) - \frac{\delta_m}{1-\delta_m} & \alpha ps(1-2\beta) \\ \beta(1-\beta) & (-2\beta^2+2\beta-1) \end{vmatrix}. \tag{33}$$

Setting $\delta_m = \delta_w = 0$ and $\alpha = 1$, we obtain

$$\begin{vmatrix} (b - \beta ps) & ps(1-2\beta) \\ \beta(1-\beta) & (-2\beta^2+2\beta-1) \end{vmatrix} = (ps-2b)\beta^2 + 2b\beta - b. \tag{34}$$

The roots of the quadratic equation $(ps-2b)\beta^2+2b\beta-b=0$ are

$$\frac{-b\mp\sqrt{b(ps-b)}}{ps-2b}. \tag{35}$$

Since $ps>2b$, $\frac{-b-\sqrt{b(ps-b)}}{ps-2b}<0<\frac{-b+\sqrt{b(ps-b)}}{ps-2b}$, and the determinant in (34) is negative when $0<\beta<\frac{-b+\sqrt{b(ps-b)}}{ps-2b}$ and positive when $\beta>\frac{-b+\sqrt{b(ps-b)}}{ps-2b}$. Therefore, $(1,\beta_1)$ is not asymptotically stable, but $(1,\beta_2)=(1,\beta^*)$ is asymptotically stable, where $\frac{b}{ps}<\frac{-b+\sqrt{b(ps-b)}}{ps-2b}<\beta^*<\frac{1}{2}$. Q.E.D.

Proof of Proposition 2. From (22),

$$\beta^*=\frac{(ps+2b)-\psi(h-pr)+\sqrt{((ps+2b)-\psi(h-pr))^2-4b(2ps-\psi(h-pr))}}{2(2ps-\psi(h-pr))}. \tag{36}$$

Let $B\equiv ps+2b-\psi(h-pr)$ and $C\equiv 2ps-\psi(h-pr)$. Then we can rewrite the above expression as $\beta^*=\frac{B+\sqrt{B^2-4bC}}{2C}$. Note that, for $\psi<\psi_1=\frac{ps-2\sqrt{b(ps-b)}}{h-pr}$, $B>0$, and $C>0$. Taking the derivative with respect to s, we obtain

$$\begin{aligned}\frac{\partial\beta^*}{\partial s} &= \frac{\{\frac{\partial B}{\partial s}+\frac{1}{2}(B^2-4bC)^{-\frac{1}{2}}(2B\frac{\partial B}{\partial s}-4b\frac{\partial C}{\partial s})\}C-(B+\sqrt{B^2-4bC})\frac{\partial C}{\partial s}}{2C^2} \\ &= \frac{p}{2C^2}\{C+(B^2-4bC)^{-\frac{1}{2}}(B-4b)C-2(B+\sqrt{B^2-4bC})\} \\ &= \frac{p}{2C^2}\{(C-2B)+(B^2-4bC)^{-\frac{1}{2}}(B(C-B)-(B^2-4bC))\} \\ &= \frac{p}{2C^2}(B^2-4bC)^{-\frac{1}{2}}\{(C-2B)(B^2-4bC)^{\frac{1}{2}}+B(C-B)-(B^2-4bC)\}.\end{aligned} \tag{37}$$

Let $A\equiv(B^2-4bC)^{\frac{1}{2}}$. Note that the determinant A is positive for $\psi<\psi_1$. Then,

$$\begin{aligned}\frac{\partial\beta^*}{\partial s} &> 0\Leftrightarrow(C-2B)A+B(C-B)-A^2>0 \\ &\Leftrightarrow -A^2-2AB-B^2+C(B+A)>0 \\ &\Leftrightarrow (B+A)(C-B-A)>0\Leftrightarrow(C-B)>A.\end{aligned} \tag{38}$$

This inequality reduces to $ps-2b>\sqrt{B^2-4bC}\Leftrightarrow\psi(h-pr)-2ps>0$, which holds for $\psi<\psi_1$. Hence, $\frac{\partial\beta^*}{\partial s}>0$.

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