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Variability in punishment, risk preferences and crime deterrence

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ABSTRACT

This work studies for the first time the effect on crime deterrence of variability in punishment under different assumptions on criminals risk preferences. We show that when criminals are risk averse, greater variability in punishment reduces the incentive to commit crimes, and that the opposite holds in the case of risk loving. The linkages between certainty of punishment, initial wealth and the incentive to commit crimes are also analyzed. We then analyze the effects of greater variability in punishment on deterrence policies founded on punishment severity, showing that this effect is positive if criminals are prudent and negative if they are imprudent. Lastly, we analyze for the first time variability in punishment as an instrument of deterrence policy. This analysis determines the optimal level of variability in the two cases of homogeneity and heterogeneity in risk preference.

1. Introduction

The idea that severity and certainty of punishment are crucial for crime deterrence dates back to the classical works of Beccaria (1764) and Bentham (1823). Starting from the seminal paper by Becker (1968) this idea has also been studied using an economic approach. This approach confirms the significance of both severity and certainty of punishment, and research often discusses their relative importance (e.g. Mungan, 2017, 2019; Pyne, 2012).[1]

A further significant element potentially affecting deterrence, which has to date been somewhat neglected, is variability in punishment. It is often the case, in fact, that the law indicates a range of possible fines rather than laying down a specific fine for a particular crime. This means that the punishment is variable rather than given.

Variability in punishment may affect agent decisions on whether or not to commit a crime when (potential) criminals are not risk neutral. The risk attitude of criminals has in fact been analyzed in previous literature, but the role of variability in punishment has never been addressed. The first aim of this work is to fill this gap.

Moreover, when agents are not risk neutral, the level of wealth they have before choosing whether to commit a crime (their initial wealth) may also affect their choice. The second aim of this work is to address this issue, also studying possible interactions between initial wealth and certainty of punishment.

A further aim of this work is to study how variability in punishment affects the optimal level of traditional crime deterrence policies, acting on punishment severity. The results of this analysis show the specific aspects of DM preferences which determine the effects of variability in this case.

Moreover, since punishment variability influences the choice on whether or not to commit a crime, it can be also directly used as an instrument for deterrence policies. The last aim of this work is to study this kind of policy, which is to my knowledge novel to the literature, and determine the optimal level of punishment variability in these interventions. This issue is analyzed considering different types of policies and it is examined both in the case where criminals have homogeneous preferences toward risk and in the case where preferences are heterogeneous. Our results in this field show that optimal variability is higher when potential criminals are risk averse or, in the case of heterogeneity in preferences, when the fraction of risk averse DMs among potential criminals is larger.

The paper proceeds as follows. Section 2 provides a brief literature overview. Section 3 examines the effects of variability in punishment for individual choices on committing crimes. Section 4 analyzes the role of initial wealth under different assumptions on preferences toward risk. Section 5 studies the consequences of variability in punishment for optimal investment in traditional deterrence policies acting on punishment severity. Section 6 studies a new kind of deterrence policy acting on punishment variability and determines its optimal level. Section 7 reconsiders this issue in the case of heterogeneity of preferences toward risk. Section 8 concludes.

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[1] Other element influencing crime deterrence studied in the literature are the length of the criminal procedure (Dušek, 2015), the credibility of threats to punish criminals (Baker and Miceli, 2021) and the degree of cooperation of suspects and the consequent possible leniency (Lundberg, 2019).

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2. Literature overview

The present paper analyzes the effects of variability in punishment on the incentive to commit crimes (and thus on crime deterrence policies) and the role of criminals' risk preferences in determining these effects. To my knowledge both the study of this issue and the approach to examining variability in punishment introduced in the present paper are novel to the literature. On the other hand, the two issues of punishment variability and criminals' risk preferences toward risk have been studied separately in two different strands of literature.

With reference to the issue of variability in punishment, we first emphasize that, although they provide indications for the punishment of different types of crimes, legal systems usually leave room for discretion in determining specific fines to impose in each judgement. This discretion is typically motivated by the idea that the specific elements of each crime, and, in particular specific mitigating and aggravating circumstances, should be taken into account (e.g. Roberts, 2011). On the other hand, this discretion is, at least potentially, limited by the fact that general legal principles and constitutional guarantees of non-discriminatory treatment require that identical crimes should be punished equally.

Despite this constraint, however, empirical literature shows that variability in punishment is wide and is often unjustifiable, since there is significant evidence of disparities in sentencing generated by racial, ethnic and gender factors (Mustard, 2001) and by the effects of emotional shock (Eren and Mocan, 2018). Other differences in sentencing derive from the different leanings or opinions of different judges with regard to the same crime (Harris and Sen, 2019). These disparities are not limited to any one legal system, and have been noted in different countries, such as the United States, to which works cited above refer, England and Wales (Pina-Sánchez and Linacre, 2013), Australia (Krasnostein and Freiberg, 2013) and some countries of Eastern Europe (Drápal, 2020). Specific interventions, such as the introduction of sentencing guidelines and principled sentences, have been introduced precisely in order to reduce unmotivated disparities, although the efficacy of these actions is controversial (Pina-Sanchez and (Pina-Sánchez and Linacre, 2014; Yang, 2014)).

In summary, the literature on punishment variability suggests the need for discretion to take account of the mitigating and aggravating circumstances of each crime, but it also shows that the resulting disparities can be unjustified. In this context, a question which remains, to my knowledge, unanswered is whether punishment variability has effects on criminal choices and whether this has potential implications for crime deterrence and thus for policies which can be implemented to enhance it. It is important to answer this question not only in order to complete the analysis of punishment effects, but also because, as outlined above, variability in punishment is very widespread in practice.

The second issue which is relevant for the present paper is criminals' own attitude toward risk. In examining this issue we first emphasize that, in general, with the exception of the literature focusing specifically on criminals, economic models in many different fields simply assume that people are either risk neutral or risk averse. On the other hand, decision theory under risk usually studies the behavior of agents as risk averse, risk neutral or risk lovers.

With reference to criminal activities, the attitude toward risk of potential criminals is the subject of a particular strand of literature, starting from the seminal paper by Becker (1968). This study suggests that offenders are a particular group of decision makers, and that we can argue they are usually risk lovers on the basis of the evidence on their sensitivity to the certainty and to the severity of punishment.

Starting from Becker's work, many studies investigate the issue of criminals preferences toward risk in more detail, but findings are not conclusive. From a theoretical standpoint, there are studies which attempt to reconcile risk aversion with the evidence mentioned by Becker (e.g. Neilson and Winter, 1997; Mungan and Klick, 2014) while other studies (e.g. Langlais, 2006) confirm Becker's conclusions. Similarly, from an empirical standpoint, some studies support the idea that criminals are more sensitive to certainty than to severity of punishment (e.g. Block and Gerety, 1995) and (Grogger, 1991) while other works challenge these findings (Friesen, 2012) and (Engel and Nagin, 2015). Moreover Friehe and Schildberg-Hörisch (2017) suggest that criminals behave as if they were risk lovers because of their lack of self-control. Lastly Khadjavi (2018) suggests that there are significantly more risk lovers in a group of criminals than in a control group (of students) but, despite this, the vast majority of criminals are risk neutral or risk averse.

Taking this debate into account, the analysis in the present paper does not introduce a specific assumption on criminals' risk preferences, but rather offers results which reveal the different implications of risk aversion, risk neutrality and risk loving. Moreover, in the same direction, the paper also aims to fill a gap in the literature on criminals' preferences toward risk. As noted above, this literature analyzes how criminals' risk attitude affects the effects of certainty and severity of punishment. Decision theory under risk, however, clearly shows that risk attitude is specifically related to variability in wealth.[2] It is thus important to study the implications of criminals' attitude toward risk on the effects of variability in punishment. Such implications are the focus of the present work. Studying them is significant for a better understanding of the mechanisms of criminal decision-making and is thus also relevant for the optimal implementation of crime deterrence policies.

3. Variability in punishment and individual choices

We study individual choices in a model similar to Becker (1968, p. 177) and Neilson and Winter (1997). The only difference is that positive initial wealth W is introduced in place of null initial wealth.

We consider a Decision Maker (henceforth DM) who decides whether to commit a crime. In the case that he commits the crime, there is a probability $p \in [0,1]$ that he is convicted and a probability $1-p$ that he is not. If the DM is not convicted his gain is G and if he is convicted he receives punishment S. This implies that DM total wealth remains W if he does not commit the crime; it becomes $W+G$ if he is not punished and $W-S$ if he is punished.

DM preferences are described by the utility function $u(.)$ with $\frac{du}{dx} = u'(.) > 0$. Therefore, when the DM does not commit the crime, his utility is given by $u(W)$ while, in the case of crime, his expected utility is given by $pu(W-S)+[1-p]u(W+G)$. The expected "economic" incentive to crime is thus:

$$M = pu(W-S)+[1-p]u(W+G)-u(W) \quad (1)$$

Lastly, introducing ethical hesitation toward implementing crime, we have that the DM commits the crime if the expected economic incentive to crime M is stronger than the ethical hesitation.[3] Assuming that the strength of the ethic hesitation is unknown, we have that the larger M is, the more likely is the choice to commit the crime. This also implies that interventions reducing M deter criminal activities.

We introduce the following definitions:

Definition 1. There is **greater certainty of punishment** if the probability that a crime is detected and subjected to fines is higher.

Definition 2. There is **greater severity in punishment** if the fine imposed when a crime is detected is higher.

[2] This idea was introduced in the seminal papers by Pratt (1964) and Rothschild and Stiglitz (1970) and was subsequently widely analyzed in the literature.

[3] Clearly, if M is negative, the DM surely chooses the no crime option.

Thus, in our model, certainty of punishment refers to variable p and severity in punishment refers to variable S. We thus have:

Proposition 1. *Greater certainty of punishment (higher p) reduces the expected economic incentive to crime M.*

Proof. Since $\frac{\partial M}{\partial p} = u(W-S) - u(W-G) < 0$, a higher p reduces M. □

Proposition 2. *Greater severity in punishment (higher S) reduces the expected economic incentive to crime M.*

Proof. Since $\frac{\partial M}{\partial S} = -pu'(W-S) < 0$, a larger S reduces M. □

These results confirm in our framework the deterrence effect of certainty and severity of punishment stated in the literature.

We now introduce the following definitions:

Definition 3. A DM is **risk averse** when $\frac{d^2u}{dx^2} = u''(.) < 0$, **risk neutral** when $u''(.) = 0$ and a **risk lover** when $u''(.) > 0$.

Definition 4. There is **variability in punishment** when the punishment is represented by a random variable, whose distribution is known, and where possible fines have given probabilities of being imposed.

Definition 4 implies that there is a range of possible fines where the punishment is determined (perhaps by a court) and the potential criminal knows the probability of getting different fines, but not the exact fine he will receive if his crime is detected.

Given this, we assume that the punishment in the case of crime detection is represented by the random variable $\tilde{S}$ whose distribution is known and whose expected value is equal to the level S defined above. The expected economic incentive to crime becomes

$$\tilde{M} = pE[u(W-\tilde{S})] + [1-p]u(W+G) - u(W) \tag{2}$$

Comparing (1) and (2) we obtain:

Proposition 3. *(a) If the DM is risk averse, the presence of variability in punishment ($\tilde{S}$ instead of S) reduces the expected economic incentive to crime ($\tilde{M} < M$).*
(b) If the DM is risk neutral, the presence of variability in punishment ($\tilde{S}$ instead of S) has no effect on the expected economic incentive to crime ($\tilde{M} = M$).
(c) If the DM is a risk lover, the presence of variability in punishment ($\tilde{S}$ instead of S) increases the expected economic incentive to crime ($\tilde{M} > M$).

Proof. We prove Statement (a). Jensen's Inequality implies that, when $u''(.) < 0$, we have $u(W - E[\tilde{S}]) = u(W-S) > E[u(W-\tilde{S})]$. This implies in turn $\tilde{M} < M$. The proofs of Statements (b) and (c) are similar. □

Proposition 3 shows that variability in punishment affects the choice of whether to commit a crime or not. The effect depends on DM attitude toward risk. If the DM is risk averse, he dislikes variability in punishment and this generates an incentive to not commit the crime. In this case, variability of punishment implies crime deterrence. The opposite incentive, and thus the opposite effect on deterrence, exists if the DM is a risk lover.

Assume now that, given that punishment is variable, we have a change in this variability which makes "extreme" outcomes (very weak punishment and very strong punishment) more probable without modifying the average level of punishment. Technically, this change in a distribution is called a mean-preserving spread and is a kind of increase in variability widely studied in the literature.[4] We thus introduce the following definition:

Definition 5. There is **greater variability in punishment** when there is a mean-preserving spread in the distribution of the random variable describing the punishment.

Letting $\tilde{S}_1$ be a mean-preserving spread on $\tilde{S}$ and $\tilde{M}_1$ the expected economic incentive to crime after the mean-preserving spread, we have:

Proposition 4. *(a) If the DM is risk averse, greater variability in punishment (a mean-preserving spread from $\tilde{S}$ to $\tilde{S}_1$) reduces the expected economic incentive to crime ($\tilde{M}_1 < \tilde{M}$).*
(b) f the DM is risk neutral, greater variability in punishment (a mean-preserving spread from $\tilde{S}$ to $\tilde{S}_1$) has no effect on the expected economic incentive to crime ($\tilde{M}_1 = \tilde{M}$).
(c) If the DM is a risk lover, greater variability in punishment (a mean-preserving spread from $\tilde{S}$ to $\tilde{S}_1$) increases the expected economic incentive to crime ($\tilde{M}_1 > \tilde{M}$).

Proof. We prove Statement (a). Ekern (1980, p. 131) shows that, when $u''(.) < 0$, we have $E[u(W-\tilde{S})] > E[u(W-\tilde{S}_1)]$. This implies in turn $\tilde{M}_1 < \tilde{M}$. The proofs of Statements (b) and (c) are similar. □

Proposition 4 complements Proposition 3. Greater variability in punishment disincentivizes crime and generates deterrence if the DM is risk averse, but it has opposite effects if the DM is a risk lover.

Moreover, it is worth emphasizing that, in the case of risk aversion, we have that certainty and variability of punishment can be used together for crime deterrence. At first glance, this conclusion may seem contradictory. But the contradiction is clearly only superficial, given the concepts of certainty and variability specified in Definition 1, 4 and 5. In fact, starting from these definitions, what our findings suggest is that, under risk aversion, deterrence is stronger when the potential criminal knows he will be punished if convicted, but does not know the exact severity of his punishment.

4. Initial wealth and attitude toward risk

In the previous section we showed that the effect of punishment variability on individual choice on whether to commit a crime or not depends on DMs attitude toward risk. In the case of no risk neutrality, this choice is also affected by initial wealth W. Although previous literature studies the relationship between wealth and crime extensively (see Sharkey et al., 2016) for a survey), this specific effect has been, to my knowledge, neglected until now. However, as discussed below, it is important to study it, because of its possible significant implications for punishment design.

The effect of initial wealth on potential criminal's choices are analyzed in the following proposition:

Proposition 5. *(a) If the DM is risk averse, the expected economic incentive to crime M is increasing in initial wealth W for a high probability of punishment ($p > p^* = \frac{u'(W)-u'(W+G)}{u'(W-S)-u'(W+G)}$ and decreasing in initial wealth W for a low probability of punishment ($p < p^* = \frac{u'(W+G)-u'(W)}{u'(W+G)-u'(W-S)}$).*
(b) If the DM is risk neutral, the expected economic incentive to crime M does not depend on initial wealth W.
(c) If the DM is a risk lover, the expected economic incentive to crime M is decreasing in initial wealth W for a high probability of punishment ($p > p^* = \frac{u'(W)-u'(W+G)}{u'(W-S)-u'(W+G)}$) and increasing in initial wealth W for a low probability of punishment ($p < p^* = \frac{u'(W+G)-u'(W)}{u'(W+G)-u'(W-S)}$).

[4] We recall that a mean-preserving spread is a change in the distribution of a random variable which spreads out one or more portions of the density function of the distribution, keeping the mean unchanged. A mean-preserving contraction generates exactly the opposite change, moving some portions of the density function of the distribution toward its center, keeping the mean unchanged.

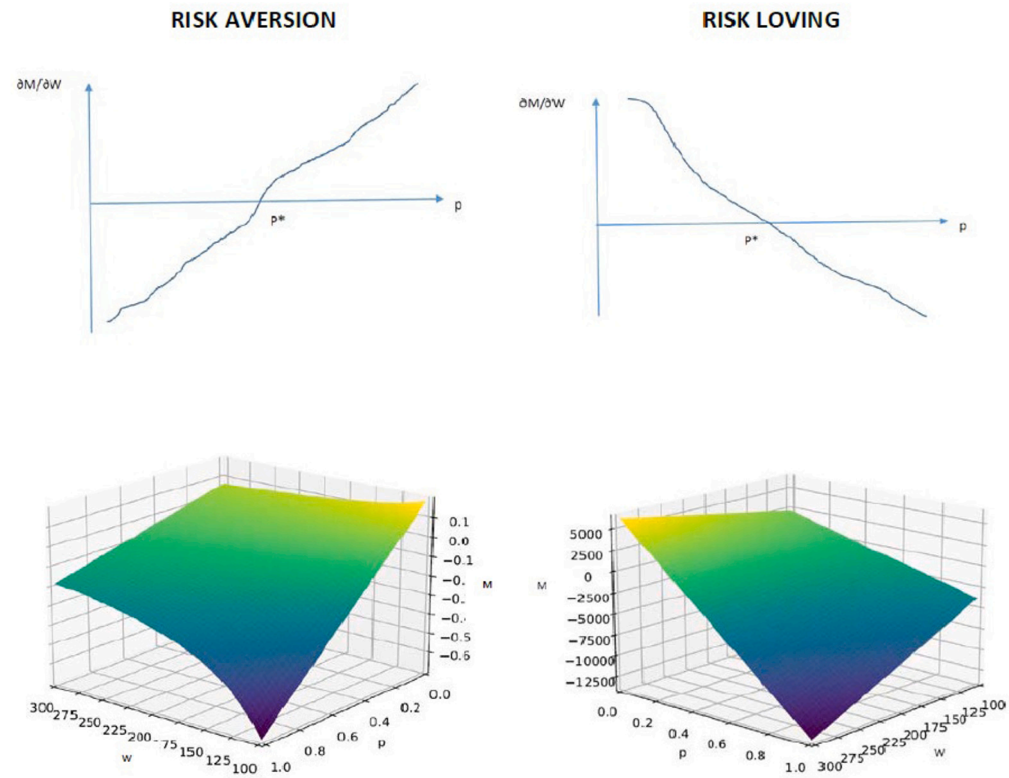

Fig. 1. The relationship between M, W and p.

Proof. We prove Statement a). Consider $M = pu(W-S)+[1-p]u(W+G)-u(W)$, defined in Section 2. We have that $\frac{\partial M}{\partial W} = pu'(W-S)+[1-p]u'(W+G)-u'(W)$. Simple computations show that, given $u''(.)<0$, we have $\frac{\partial M}{\partial W} = u'(W+G)-u'(W)<0$ for $p=0$, $\frac{\partial M}{\partial W} = u'(W-P)-u'(W)>0$ for $p=1$, and $\frac{\partial M}{\partial W} = 0$ for $p=p^* = \frac{u'(W)-u'(W+G)}{u'(W-P)-u'(W+G)}$. Again since $u''(.)<0$, we have that $\frac{\partial M^2}{\partial W \partial p} = u'(w-P)-u'(W+G)>0$. These results together imply that $\frac{\partial M}{\partial W}$ is an increasing function of p, negative for $p=0$, positive for $p=1$ and null for $p=p^*$, proving the proposition. The proofs of Statements b) and c) are similar. □

The relationship between wealth and crime has been widely studied in the literature. Proposition 5 provides new insights into this, suggesting that the relationship interacts with the level of certainty of punishment p and with DM attitude toward risk. A qualitative representation of this picture is shown in Fig. 1.[5]

This has significant policy implications. When the DM is risk averse and certainty of punishment is low, a policy increasing wealth generates crime deterrence. In other cases (e.g. when there is risk aversion and high p or risk loving and low p), however, the effects of changes in wealth, and thus the effects of policies, vary and an increase in wealth may even weaken deterrence.

A further aspect of the role of the level of initial wealth which is interesting to analyze is how this level affects the sensitivity of the economic incentive to commit crime with respect to a change in the level of certainty of punishment (i.e. $\frac{\partial M}{\partial p}$ determined in Proposition 1). In particular, Proposition 1 showed that greater certainty of punishment reduces the incentive to commit crimes. This reduction is affected by the level of initial wealth. In this respect, we have that:

Proposition 6. *(a) If the DM is risk averse, the sensitivity of crime incentive to the level of certainty of punishment ($\frac{\partial M}{\partial p}$) is an increasing function of initial wealth.*
(b) If the DM is risk neutral, the sensitivity of crime incentive to the level of certainty of punishment ($\frac{\partial M}{\partial p}$) does not depend on initial wealth.
(c) If the DM is a risk lover, the sensitivity of crime incentive to the level of certainty of punishment ($\frac{\partial M}{\partial p}$) is a decreasing function of initial wealth.

Proof. Since $\frac{\partial^2 M}{\partial p \partial W} = u'(W-S)-u'(W+G)$, we have that $\frac{\partial^2 M}{\partial p \partial W}$ is positive when $u''(.)<0$, null when $u''(.)=0$ and negative when $u''(.)>0$. □

Moreover, since the effect of an increase in the certainty of punishment p on the economic incentive M is negative, we clearly have that a measure of the impact of the policy, and thus of its efficacy, can be provided by its absolute value. This implies in turn that:

Corollary 1. *The impact on the economic incentive to commit a crime of certainty of punishment: (a) is decreasing in initial wealth when the DM is risk averse; (b) does not depend on wealth if the DM is risk neutral; (c) is increasing in wealth when the DM is a risk lover.*

The implication of these results is that the efficacy of certainty of punishment in reducing the incentive to commit crimes depends on wealth. In particular, in the case where we assume that the DM is risk averse, our results suggest that the efficacy is lower for wealthy people. This result may be related to the literature which argues that wealthy people are more inclined to commit crimes because they are relatively more able to cover monetary fines and suggests, for this reason, the introduction of day-fines or non-pecuniary sanctions (e.g. Kantorowicz and E., 2015). Proposition 6 provide a further argument in this direction, in the case where the DMs are risk averse. We find, however, that the same conclusion does not hold in case of risk loving. Thus, with reference to the specific argument based on Proposition 6, the advantage of introducing day-fines depends on the features of criminals' preferences toward risk.

[5] The two diagrams showing M as a function of p and W in case of risk aversion and risk loving are obtained by using respectively the two illustrative functions: logarithmic utility and CRRA utility with an index of relative risk aversion equal to −1.

5. Variability in punishment and deterrence policy on severity

The previous section analyzed the effect of variability in punishment on individual choices. This section examines a different aspect potentially affected by this variability: optimal investment in a crime deterrence policy based on the severity of punishment. For this purpose, given the assumptions on DM preferences introduced in Section 2, we now assume that a regulator can influence the level of penalty S by investing in a specific policy.[6]

We assume that, if a crime is committed, the damage to society can be quantified in D. Consistently with the assumptions introduced in Section 2, we assume that the potential criminal commits the crime if his economic incentive is larger than his ethical hesitation. Assuming that the ethical hesitation is uniformly distributed between 0 and H, and that, for simplicity, M is bounded in the interval $[0, H]$, the fraction of DMs who commit the crime is equal to $\frac{M}{H}$. The regulator can affect criminal's choice by acting on the level of penalty. This level is now thus $S = S_0 + a$ where a is the policy variable. The cost of investing in the deterrence policy is described by function $C(a)$, where $C'(a) = \frac{dC}{da} > 0$ and $C''(a) = \frac{d^2C}{da^2} > 0$. Given all this, the regulator chooses a in order to minimize social cost $T(a)$, i.e.:

$$min_a T(a) = min_a \frac{M}{H} D + C(a) \tag{3}$$

where M is the quantity defined in (1) and is thus a function of a. When there is no variability in punishment, the optimal level of policy variable a^* is determined by the first-order-condition:

$$-pu'(W - S_0 - a^*)D/H + C'(a^*) = 0 \tag{4}$$

We assume that $C''(a)$ is sufficiently large for every value of a to ensure that the second-order condition $T''(a) > 0$ is satisfied.

Before examining the effects of variability in punishment on optimal investment in the deterrence policy we recall the concept of prudence introduced in the seminal paper by Kimball (1990) and widely used in the literature on decision theory.

Definition 6. A DM is **prudent** if $\frac{d^3u(x)}{dx^3} = u'''(.) > 0$ and **imprudent** if $\frac{d^3u(x)}{dx^3} = u'''(.) < 0$

To complete the definition, recall that risk neutrality also implies prudence neutrality (i.e. $u'''(.) = 0$).

We now introduce variability in punishment by replacing the constant S_0 with the random variable $\tilde{S}_0$. We obtain that the optimal level of policy variable a^{**} is determined by the first-order condition:

$$-p\mathbb{E}[u'(W - \tilde{S}_0 - a^{**})]D/H + C'(a^{**}) = 0 \tag{5}$$

By comparing (4) and (5) we obtain:

Proposition 7. *(a) If the DM is prudent, the presence of variability in punishment increases optimal investment in the deterrence policy based on punishment severity ($a^{**} > a^*$).*
(b) If the DM is risk neutral, the presence of variability in punishment has no effect on optimal investment in the deterrence policy based on punishment severity ($a^{**} = a^*$).
(c) If the DM is imprudent, the presence of variability in punishment decreases optimal investment in the deterrence policy based on punishment severity ($a^{**} < a^*$).

[6] The literature assumes in some cases that deterrence policy acts on probability p (e.g. Baker and Miceli, 2021; Miceli and Mungan, 2021). In the present paper, given that we study variability in punishment, we focus on a policy acting on S. On possible different choices for policy instruments, see also Miceli (2018).

Proof. We prove statement a). Jensen's Inequality implies that, if $u''' > 0$, $-p\mathbb{E}[u'(W-\tilde{S}_0-a^*)]D/H+C'(a^*) < -pu'(W-P_0-a^*)D/H+C'(a^*) = 0$. By the second-order condition, this implies $a^{**} > a^*$. The proofs of Statements b) and c) are similar. □

Lastly, by introducing a mean-preserving spread in variable $\tilde{S}_0$ we obtain:

Proposition 8. *(a) If the DM is prudent, greater variability in punishment increases optimal investment in the deterrence policy based on punishment severity ($a^{**} > a^*$).*
(b) If the DM is risk neutral, greater variability in punishment has no effect on optimal investment in the deterrence policy based on punishment severity ($a^{**} = a^*$).
(c) If the DM is imprudent, greater variability in punishment decreases optimal investment in the deterrence based acting on punishment severity ($a^{**} < a^*$).

Proof. The proof is similar to that of Proposition 7, using Ekern's (1980) results instead of Jensen's Inequality. □

Section 2 showed that risk aversion (risk loving) is sufficient to ensure that greater variability in punishment reduces (increases) individual incentive to commit a crime. Propositions 7 and 8 show that the same assumption is not sufficient to generate clear-cut conclusions on optimal investment in a deterrence policy acting on punishment severity, which depends on prudence (imprudence).

The fact that prudence (imprudence) is relevant in decision problems under uncertainty is not new. In decision theory under risk, in fact, prudence has been shown crucial for saving choice under uncertainty (Leland, 1968), self-protection models (Eeckhoudt and Gollier, 2005; Menegatti, 2009), portfolio choice (Chiu et al., 2012), rent-seeking games (Treich, 2010; Menegatti, 2021) and stochastic dominance (Levy, 2006). Propositions 7 and 8 show that prudence is also important for optimal investment in deterrence policies acting on punishment severity when there is variability in punishment.

A possible interpretation of these results is related to the meaning of being prudent, shown, in different ways, by Eeckhoudt and Schlesinger (2006) and Menegatti (2007). In general, when a DM is prudent, he desires to have a larger expected wealth when he faces a risk. This means, in the specific case studied in the present model, that the DM desires to have a lower expected punishment when the punishment is variable. This implies that, when punishment is variable, more severe punishment, which generates a greater expected reduction in wealth in case of conviction, is more disliked by the potential criminal, when he is prudent. This makes the optimal investment in a policy based on severity of punishment larger under prudence.

The literature has moreover shown that the presence of prudence together with risk aversion is confirmed by empirical evidence (e.g. Deck and Schlesinger, 2010; Ebert and Wiesen, 2014) and that there are some theoretical links between these two aspects of preferences toward risk (Menegatti, 2001, 2014) and (De Donno and Menegatti, 2020). So, considering the results in Sections 2 and 4 together, we obtain that, in the case where risk aversion and prudence occur contemporaneously, greater variability in punishment leads to an increase both in crime deterrence related to individual incentives and in optimal investment in a deterrence policy acting on punishment severity.

6. Optimal variability in punishment

Section 5 examined the effect of punishment variability on deterrence policy based on punishment severity. The analysis in Section 3, however, suggests that variability affects crime choices, implying that variability itself can be used as an instrument for deterrence policies. This opens space for the study of a further aspect: the issue of determining the socially optimal level of punishment variability, to be obtained by means of policy actions.

In order to analyze this, we reconsider the model examined in Section 5, but we replace deterrence policy based on punishment severity with a policy based on punishment variability. According to Definition 5, punishment variability can be increased by introducing a mean-preserving spread in the distribution of the random variable describing punishment.

In order to model these kinds of change we consider a form of random punishment partially more specific than that studied in Section 3. In particular we assume that punishment $\tilde{S}$ can take three different values S_1, S_2 and S_3 (where $S_1 < S_2 < S_3$) with probabilities q_1, q_2 and q_3 respectively. In this case the expected economic incentive to crime introduced in Eq. (1) becomes:

$$\hat{M} = p[q_1 u(W-S_1)+q_2 u(W-S_2)+q_3 u(W-S_3)]+[1-p]u(W+G)-u(W) \quad (6)$$

We assume for simplicity that $S_2 = \frac{S_1+S_3}{2}$. Results similar to those derived below can be obtained in a more general case.

In this context, we consider two ways of obtaining a mean-preserving spread. First we consider the following change in probabilities q_1, q_2 ad q_3:

$$\hat{M} = p[(q_1+\alpha/2)u(W-S_1)+(q_2-\alpha)u(W-\frac{S_1+S_3}{2}) + (q_3+\alpha/2)u(W-S_3)]+[1-p]u(W+G)-u(W) \quad (7)$$

where $0 < \alpha \leq q_2$. This change in probabilities leaves the mean of random punishment unchanged but spreads out a portion of probability density toward the tails of the distribution. Notice that this change does not change the different possible fines and affects only probabilities.

A different mean-preserving spread can be obtained by assuming that $q_1 = q_3$ and considering the following changes in possible fines:

$$\hat{M} = p[q_1 u(W-(S_1-\alpha))+q_2 u(W-\frac{S_1+S_3}{2}) + q_1 u(W-(S_3+\alpha))]+[1-p]u(W+G)-u(W) \quad (8)$$

where $0 < \alpha \leq S_1$ This mean-preserving spread does not directly affect probabilities q_1, q_2 and q_3 but spreads out the probability density by reducing the minimum fine S_1 and by increasing the maximum fine S_3, that is by acting on the extreme possible fines S_1 and S_3 making them even more extreme.

We now examine optimal punishment variability from a social point of view by assuming that a regulator can affect the distribution of random punishment by acting on parameter α in one of the ways described by Eqs. (7) and (8). Given this premise, we reconsider the approach in Section 5 by assuming that the regulator chooses α such that:

$$min_a T(a) = min_a \frac{\hat{M}}{H} D + C(a) \quad (9)$$

where $\hat{M}$ can be either that in Eq. (7) or that in Eq. (8).

We thus consider optimal deterrence policy made by using punishment variability as an instrument. When $\hat{M}$ is described by (7) we have a policy *increasing probabilities of extreme fines*. When $\hat{M}$ is described by (8) we have a policy *increasing levels of extreme fines*.

Assuming that $\hat{M}$ is described by (7), the optimal level of α^* is determined by the following first-order condition:

$$p[\frac{1}{2}u(W-S_1)-u(W-\frac{S_1+S_3}{2})+\frac{1}{2}u(W-S_3)]+C'(\alpha^*)=0 \quad (10)$$

Assuming that $\hat{M}$ is described by (8), the optimal level of α^* is determined by the following first-order condition:

$$pq_1[u'(W-S_1+\alpha^*)-u'(W-S_3-\alpha^*)]+C'(\alpha^*)=0 \quad (11)$$

Different results can be obtained from these two conditions. We start by examining a simplified case where $C(\alpha)=0$, which is the case where the policy acting on punishment variability has no cost. We emphasize that this case is important not only as a benchmark. In fact, unlike the case of policy deterrence using severity of punishment studied in Section 5 which usually requires costly investment in gathering proof or hiring better lawyers, the cost of the punishment variability policy may be very low or even almost null. This is because this policy can often be implemented by rescheduling different fines (or their probabilities) simply by changing rules and codes by means of law.

We obtain that:

Proposition 9. *If $C(\alpha) = 0$, when considering a policy acting on the probabilities of extreme fines, we have that:*
(a) If the DM is risk averse, the optimal choice is to set α at its maximum level ($\alpha = q_2$).
(b) If the DM is risk neutral, there is no optimal choice for α.
(c) If the DM is a risk lover, the optimal choice is to set α at its minimum level ($\alpha = 0$).

Proof. We first prove a). By the definition of a concave function, we have that if $u(.)$ is concave then $\lambda u(W-S_1)+(1-\lambda)u(W-S_3) < u(W-\lambda S_1+(1-\lambda)S_3)$. Letting $\lambda = \frac{1}{2}$ we thus obtain that, in case of risk aversion ($u''(.)<0$), the term $p[\frac{1}{2}u(W-S_1)-u(W-\frac{S_1+S_3}{2})+\frac{1}{2}u(W-S_3)]$ is negative. Since $C(\alpha)=0$, this implies that the left-hand side of (10) is negative for every value of α and (10) is never satisfied. This implies that the optimal choice is choosing the maximum possible value for α. In statement b) function $u(.)$ is linear implying that the left-hand side of (10) is always null. This implies in turn that there is no optimal choice for α.

Lastly the proof for (c) is similar to that for a) considering the definition of a convex function instead of that of a concave function. □

Proposition 10. *If $C(\alpha) = 0$, when considering a policy acting on the levels of extreme fines, we have that:*
(a) If the DM is risk averse, the optimal choice is to set α at its maximum level ($\alpha = S_1$).
(b) If the DM is risk neutral, there is no optimal choice for α.
(c) If the DM is a risk lover, the optimal choice is to set α at its minimum level ($\alpha = 0$).

Proof. We first prove (a). When $u''(.)<0$, since $S_3 > S_1$ and $a^* > 0$, the term $pq_1[u'(W-S_1+\alpha^*)-u'(W-S_3-\alpha^*)]$ is negative. Since $C(\alpha)=0$, this implies that the left-hand side of (11) is negative for every value of α and (11) is never satisfied. This implies that the optimal choice is choosing the maximum possible value for α.

In statement (b) function $u(.)$ is linear, implying that the left-hand side of (11) is always null. This implies in turn that there is no optimal choice for α.

Lastly the proof for (c) is similar to that for (a) considering that, when $u''(.)>0$, $u'(.)$ is increasing instead of decreasing. □

The results in Propositions 9 and 10 are coherent with those obtained in Section 3. If we assume that the policy acting on punishment variability has no cost, the optimal policy only depends on the effect of the variability on deterrence. In the case of risk aversion, variability reduces crime incentive, so the optimal choice is the maximum of variability. On the other hand, in the case of risk loving, variability increases crime incentive, so the optimal choice is the minimum of variability. Lastly, in the case of risk neutrality, variability has no effects on crime incentive, implying that there is no optimal choice.

Consider now the case where $C(\alpha)$ is not null. It is worth noting that the cost of a policy increasing punishment variability can be simply interpreted as a cost related to the implementation of the policy, but it can also have a different interpretation. As noted in Section 2, legal systems positively assess equality in punishment of identical crimes. This is related to the idea of ensuring equal treatment, usually indicated by general legal principles and constitutional laws and often enhanced by sentencing guidelines and principled sentencing. In this direction, cost $C(\alpha)$ can be seen as a social cost of punishment variability measuring the cost of there being some disparities and potentially unequal treatments.

We start by studying the case where, as in Section 5, $C'(\alpha) > 0$ and $C''(\alpha) > 0$. This case can be interpreted according to the reasoning above. More specifically the assumption that $C'(\alpha)$ is increasing and convex describes the idea that a larger variability generates a larger social cost and that marginal cost of variability is increasing. Lastly, as in Section 5, we assume that $C''(\alpha)$ is sufficiently large to ensure the second-order condition is satisfied. In this case we obtain the following:

Proposition 11. *Considering a policy acting on the probabilities of extreme fines we have that:*
(a) If the DM is risk averse, the optimal choice is to set α at the value determined by Eq. (10).
(b) If the DM is risk neutral, the optimal choice is to set α at its minimum level ($\alpha = 0$).
(c) If the DM is a risk lover, the optimal choice is to set α at its minimum level ($\alpha = 0$).

Proof. The proof is similar to that of Proposition 9. In case of statement a) the first addend of the left-hand side of (10) is negative for the reason shown in Proposition 9. The addend $C'(\alpha)$ is now positive. The optimal choice a^* is thus that which makes the absolute value of the addends of the left-hand side of (10) equals.

In the case of statement b) the left-hand side of (10) is equal to $C'(\alpha)$ and is thus positive, implying that the optimal choice is the minimum level of α.

Similarly, in case of statement c), all terms in the left-hand side of (10) are positive and the optimal choice is the minimum level of α. □

Proposition 12. *When considering a policy acting on the levels of extreme fines we have that:*
(a) If the DM is risk averse, the optimal choice is to set α at the value determined by Eq. (11).
(b) If the DM is risk neutral, the optimal choice is to set α at its minimum level ($\alpha = 0$).
(c) If the DM is a risk lover, the optimal choice is to set α at its minimum level ($\alpha = 0$).

Proof. The proof is similar to that of Proposition 10. In case of statement (a) the first addend of the left-hand side of (11) is negative for the reason shown in Proposition 10. The addend $C'(\alpha)$ is now positive. The optimal choice a^* is thus that which makes the absolute value of the addends of the left-hand side of (11) equals.

In the case of statement (b) the left-hand side of (11) is equal to $C'(\alpha)$ and is thus positive, implying that the optimal choice is the minimum level of α.

Similarly, in case of statement (c), all terms in the left-hand side of (11) are positive and the optimal choice is the minimum level of α. □

When a cost for the policy of increasing punishment variability is introduced, some results change. In the case of risk loving, the optimal choice was the minimum of variability even without the cost and the introduction of a cost of variability simply reinforces this result. In the case of risk neutrality, the cost makes an increase in variability not desirable since the policy has no effect on deterrence and there is thus no reason to pay the cost. Lastly, in the case of risk aversion, the conclusion that the optimal choice was the maximum of variability, obtained in the absence of cost, does not hold when the cost is introduced. The optimal choice is now obtained in order to balance the positive effect of variability on deterrence and the cost of the policy. This is why, in this case, we now have that, in general, the optimal level of variability is an intermediate level.[7]

A possible interpretation of these results can be obtained assuming that, as discussed above, the cost $C(\alpha)$ is the social cost of there being disparities between offenders and potentially unequal treatments. In this circumstance, in the case of DM risk aversion, there is a trade-off between the positive effect of variability on deterrence and its possible negative effect on equality of treatment.[8] This trade-off determines the intermediate choice for α shown in Statements a) of Propositions 9 and 10. On the contrary, however, in the case where criminals are risk lovers, the effects of punishment variability on deterrence suggest, as shown above, that optimal policy is to minimize variability. So, in this case, the indication from the effect on deterrence and the indication from equality in treatment are in the same direction and reinforce each others. This trade-off is further discussed in Section 8.

The analysis above assumes that function $C(\alpha)$ is monotonically increasing, representing the idea that more disparities generate a larger social cost. On the other hand, however, it may also be very costly to achieve a very a low level of variability because it has high organizational costs. This implies, in turn, that a more plausible assumption on function $C(\alpha)$ may be that it is U-shaped with $C'(\hat{\alpha})) = 0$ for the specific level of variability $\hat{\alpha}$, $C'(\alpha)$ negative for low levels of α ($\alpha < \hat{\alpha}$), $C'(\alpha)$ positive for high levels of α ($\alpha > \hat{\alpha}$) and $C''(\alpha) > 0$.[9]

In this case, we have that:

Proposition 13. *When considering a policy acting on the probabilities of extreme fines we have that the optimal choice is to set α at the value determined by Eq. (10).*

Proof. Similar to the proof of Proposition 11. □

and

Proposition 14. *When considering a policy acting on the levels of extreme fines we have that the optimal choice is to set α at the value determined by Eq. (11).*

Proof. Similar to the proof of Proposition 12. □

Propositions 13 and 14 show that, in the case of U-shaped cost of variability, an optimal level of variability different from 0 is determined for every kind of DM preference toward risk and not only when criminals are risk averse. This different result is due to the very high cost of achieving low variability, now introduced into the model.

However, the optimal level of variability obtained is different according to whether the DM is risk averse, risk neutral or a risk lover. In particular, we have that:

Proposition 15. *Letting respectively α_{RA}, α_{RN} and α_{RL} be the optimal levels for α when the DM is risk averse, risk neutral or a risk lover, we have that, both for a policy acting on the probabilities of extreme fines and for policy acting on the levels of extreme fines, $\alpha_{RA} > \alpha_{RN} > \alpha_{RL}$.*

Proof. We prove the proposition for the case of a policy acting on the probabilities of extreme fines. The proof for a policy acting on the levels of extreme fines is similar.

When the DM is risk averse, the first addend of (10) is negative. This implies that (10) holds for a positive value of $C'(\alpha)$, implying in turn that $\alpha_{RA} > \hat{\alpha}$. When the DM is risk neutral, the first addend of (10) is null. This implies that (10) holds for a null value of $C'(\alpha)$, implying

[7] The optimal level of α is determined by Eqs. (10) and (11) in the cases associated with the two kinds of policy examined. In general, these conditions determine internal solutions (i.e. values of α^* intermediate between its minimum and its maximum levels). The case of a corner solution cannot, however, in principle be excluded.

[8] We emphasize that disparities in sentencing based on discrimination are of course completely unacceptable. This case can be introduced in our model simply assuming that $C(\alpha)$ is infinite. It should be noted, however, that this would imply removing all kinds of variability in punishment and not only policies increasing punishment variability, and would thus exclude all forms of discretion in judgement.

[9] We also introduce the technical assumption that $\lim_{\alpha\to 0} C'(\alpha) = -\infty$.

in turn that $\alpha_{RN} = \hat{\alpha}$. When the DM is a risk lover, the first addend of (10) is positive. This implies that (10) holds for a negative value of $C'(\alpha)$, implying in turn that $\alpha_{RL} < \hat{\alpha}$. Previous inequalities considered together prove the proposition. □

In conclusion, in the case of U-shaped cost of variability, optimal variability is always positive, but it is also lower when the DM is a risk lover, intermediate when the DM is risk neutral and higher when the DM is risk averse.

Lastly, it is also worth noting, in this sense, that cost $C(\alpha)$ can be different for policies increasing probabilities of extreme fines and policies increasing levels of extreme fines. The two kinds of disparity, determined in the two cases, are indeed different, and it is thus possible that they are evaluated differently from a social standpoint. This clearly pertains to ethical reasoning at the basis of a preference for equality between individuals and lies beyond the scope of the present work. As noted above, however, the analysis in this section provides a formalized examination of the possible interactions between the two goals of deterrence and equal treatment when variability in punishment is used as a policy instrument. This analysis is thus potentially useful for future studies on this issue.

7. Heterogeneity in preferences toward risk

All the results on deterrence policies obtained in Section 6 are derived under the assumption that preferences toward risk are homogeneous among criminals, or, more specifically, under the assumption that all criminals are either risk averse, risk neutral or risk lovers. A different situation arises if criminals are heterogeneous, that is, if some of them are risk averse and some are risk lovers. This section provide some findings in this situation.[10]

Before re-examining the model of Section 6 under heterogeneity we provide a first preliminary result related to the conclusions of Section 3. The analysis in Section 3 implies that we have a reduction in the incentive to commit crime for risk averse DMs and an increase in it for risk lovers. This implies that, introducing heterogeneity in the framework studied in Section 3, we obtain:

Proposition 16. *In the case of heterogeneity in risk preferences, greater variability in punishment weakly decreases (either decreases or leaves unchanged) the portion of risk averse among people committing crimes and weakly increases (either increases or leaves unchanged) the portion of risk lovers among people committing crimes.*[11]

We now reconsider the model of Section 6. Assume the population is heterogeneous with regard to risk attitude and that a fraction β of population consists of risk averse DMs and a fraction $1-\beta$ consists of risk lovers. Risk averse DMs have utility function $u(.)$ where $u'(.) > 0$ and $u''(.) < 0$. Risk lovers have utility $v(.)$ where $v'(.) > 0$ and $v''(.) > 0$. We assume that the ethical hesitation is uniformly distributed between 0 and H in each of the two groups and is thus independent from the attitude toward risk. In this context, the regulator chooses punishment variability in order to solve the following problem:

$$min_a T(a) = min_a \frac{\bar{M}}{H} D + C(a) \quad (12)$$

where

$$\bar{M} = \beta[p[(q_1+\alpha/2)u(W-S_1)+(q_2-\alpha)u(W-\frac{S_1+S_3}{2}) + (q_3+\alpha/2)u(W-S_3)]+ [1-p]u(W+G)-u(W)] + (1-\beta)[p[(q_1+\alpha/2)v(W-S_1)+ (q_2-\alpha)v(W-\frac{S_1+S_3}{2})+(q_3+\alpha/2)v(W-S_3)]+[1-p]v(W+G)-v(W)] \quad (13)$$

when the policy on punishment variability acts on the probabilities of extreme fines and where

$$\bar{M} = \beta[p[q_1u(W-S_1+\alpha)+q_2u(W-\frac{S_1+S_3}{2})+q_1u(W-S_3-\alpha)]]+ [1-p]u(W+G)-u(W)+(1-\beta)[p[q_1v(W-S_1+\alpha)+ q_2v(W-\frac{S_1+S_3}{2})+q_1v(W-S_3-\alpha)]+[1-p]v(W+G)-v(W)] \quad (14)$$

when the policy on punishment variability acts on the levels of extreme fines.

The first-order condition in the case described by (13) is:

$$\beta p[\frac{1}{2}u(W-S_1)-u(W-\frac{S_1+S_3}{2})+\frac{1}{2}u(W-S_3)]+ (1-\beta)p[\frac{1}{2}v(W-S_1)-v(W-\frac{S_1+S_3}{2})+\frac{1}{2}v(W-S_3)]+C'(\alpha^*)=0 \quad (15)$$

where the first addend of the left-hand side is negative and the two other addends are positive.

The first-order condition in the case described by (14) is:

$$\beta pq_1[u'(W-S_1+\alpha)-u'(W-S_3-\alpha)]+ (1-\beta)pq_1[v'(W-S_1+\alpha)-v'(W-S_3-\alpha)]+C'(\alpha^*)=0 \quad (16)$$

where the first addend of the left-hand side is negative and the two other addends are positive.

As in previous sections, we assume that the second-order condition is satisfied in both problems. Moreover, we focus on the case of U-shaped $C(\alpha)$ which, as shown in Section 6, is probably the most plausible representation of variability costs.

All this implies that:

Proposition 17. *The optimal level of α is determined by Condition (15) in the case of a policy acting on the probabilities of extremes fines and by Condition (16) in the case of a policy acting on the levels of extremes fines.*

Proof. The proof is similar to that of Propositions 11 and 12. □

In this context, since a fraction of criminals consist of risk averse people and another fraction consist of risk lovers, the two first terms in (15) and (16) have opposite signs. Lastly the third term is the marginal cost of the deterrence policy $C'(\alpha)$. This means that the optimal level of punishment is determined in order to balance three aspects: the deterrence effect on risk averse criminals of an increase in variability, the increase in the incentive to crime that greater variability generates for those criminals who are risk lovers and the marginal cost of the policy.

Lastly the level of α clearly depends on the fractions of criminals who are respectively risk averse and risk lovers. In particular:

Proposition 18. *The optimal level of α is an increasing function of the fraction of criminals who are risk averse (β).*

Proof. We prove the proposition for a policy acting on the probabilities of extreme fines. If β increases, the absolute value of the negative addend of the left-hand side of (15) increases and the absolute value of the positive addend decreases. This implies that for $\alpha = \alpha^*$ the left-hand side of (15) is negative and (15) does not hold. Because of the second-order condition, the new value of α ensuring that the first-order condition holds must be $\alpha^{**} > \alpha^*$. A similar proof holds in case of a policy acting on the levels of extreme fines. □

[10] Similarly, in Section 5 we assumed that all criminals are either prudent, imprudent or prudence neutral. In this case too we could introduce heterogeneity. However, since the question of DM prudence or imprudence is more technical, we leave this further analysis for future research.

[11] Notice that both changes are weak since the presence of ethical hesitation implies there is no automatism between a change in the incentive to commit crime and a change in DM's choice of whether to commit it.

The meaning of this last result is simple. When the fraction of risk averse criminals increases there is an incentive for the regulator to increase punishment variability since the fraction of criminals for which greater variability implies deterrence is larger. The opposite holds when the fraction of risk lovers increases.

8. Discussion and conclusion

This paper examines the effect of variability in punishment when criminals have different kinds of preference toward risk. The analysis studies both individual choices on whether to commit a crime or not and the implications of these choices for different possible deterrence policies.

With reference to individual choices we first show that punishment variability affects DM choice on whether to commit a crime, since greater variability makes potential criminals less inclined to offend if they are risk averse and more inclined if they are risk lovers. Moreover risk aversion/neutrality/loving affects the interaction between initial wealth and certainty of punishment in determining the individual incentive to commit crimes.

With reference to deterrence policies, we first show that a traditional deterrence policy based on the severity of punishment has effects, when punishment is variable, depending on a different aspect of DM preferences toward risk: the fact that they are prudent or imprudent. Moreover, since punishment variability affects individual choices, a new policy using variability as deterrence instrument is possible. We show how the optimal level of punishment variability can be determined in this context both when the policy acts on the probabilities of extreme fines and when it acts on the levels of extreme fines. Moreover, we derive analogous results when DMs have heterogeneous preferences toward risk, showing that, in this case, optimal policy also depends on the fractions of criminals who are risk averse and risk lovers.

The results obtained in this work highlight some reasons why variability in punishment can generate positive effects on crime deterrence and may thus, in some cases, be partially desirable. These results may appear to conflict with the attempt to minimize variability in sentencing, which characterizes many legal systems aiming to reduce disparities in the treatment of individuals.

There are many possible explanations for this potential contradiction. First, the design of legal systems may simply neglect the reasons highlighted in the present work. Or it may be believed that the social cost of disparity is much higher than the benefits of variability for deterrence. In both these cases, legal systems choose to minimize variability, although in the first of them this choice may be sub-optimal.

Second, as demonstrated in the present work, no variability (or very low variability) is optimal when all or a large portion of criminals are risk lovers. In this case, there is clearly no contradiction between the conclusions of the present work and the attempt to reduce disparity in sentencing. There is however no current consensus on the risk attitude of potential criminals, and, in this respect, the findings presented in the present work also suggest the need for clear-cut conclusions on criminals' attitude toward risk for the design of optimal crime deterrence policies.

Moreover, beyond the arguments noted above, a further important element is that not every kind of variability is desirable on the basis of the conclusions obtained in the present work. In order to clarify this point, consider the specific form of variability defined in Section 3. In Section 3 we defined variability as a situation where the punishment is a random variable with a known distribution. In the real world, however, there are some kinds of variability which are not related to randomness.

Recall that in Section 2, we noted that the literature suggests that some disparities in sentencing are related to social discrimination in terms of racial, ethical and gender characteristics. It is clear that this kind of disparity will generate variability in punishment at aggregate level, but not randomness for each individual. Each individual, in fact, knows his race, ethic group and gender, and if variability is closely related to these aspects, can predict his individual punishment.[12]

This implies that, as well as being inherently socially unacceptable, variability in sentencing related to social discrimination is not useful for crime deterrence. This conclusion also clarifies that the potential trade-off between equal treatment and variability as an instrument of crime deterrence does not pertain to variability due to social discrimination.

Lastly, this conclusion also provides an indication on how legal systems should deal with variability in punishment. Disparities in sentencing due to social discrimination should always be fought and, if possible, removed. On the other hand, a component of pure randomness in sentencing, not ascribable to individual social features of the criminal but rather, for instance, to the individual leanings and opinions of each judge on the seriousness of the crime (a further source of disparity noted in Section 2), may, if not excessive, even have positive effects.

From an operative standpoint, this would suggest increasing the rotation of judges in courts in order to raise the level of randomness in the mechanism of attribution of a trial to a specific judge. However, like other potential forms of operative implementation of the indications derived from the results of the present paper, this requires specific analysis and could fruitfully be the object of future research.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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[12] Consider the following paradoxical example. Assume that we know that punishment for an individual with social feature A is always S_A and punishment for an individual with social feature B is always S_B. In this case we have variability in punishment at aggregate level but no randomness at individual level since each individual knows if he is of type A or type B.

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