

UNIVERSITÀ DEGLI STUDI DI SIENA



QUADERNI DEL DIPARTIMENTO
DI ECONOMIA POLITICA E STATISTICA

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In Dubio Pro Reo
Behavioral explanations of
pro-defendant bias in procedures

n. 637 – Maggio 2012



Abstract - The standard model of optimal deterrence predicts that the probability of wrongful conviction of the innocent is, at the margin, as detrimental to deterrence as the wrongful acquittal of guilty individuals. We extend the model in several directions: using expected utility as well as non-expected utility to consider the role of risk aversion, non-linear probability weighting and loss aversion. We also consider how relevant emotions such as guilt, shame and indignation play out. Several of these factors support the intuition that wrongful convictions of the innocent do have a larger detrimental impact on deterrence and thus the policy implications are reconciled with the widely shared maxim in *dubio pro reo*. We then draw some theoretical implications such as a novel justification for the different standards of proof in criminal vs civil law as well as other policy implications.

Keywords: wrongful convictions, Type I errors, wrongful acquittals, Type II errors, evidence, optimal under-deterrence, behavioral economics, risk aversion, loss aversion, prospect theory, prelec function

JEL classification: K14, K41, K42.

Our thanks go to the participants to the CESifo 2011 Law & Economics workshop for their useful suggestions. We also thank the Free University of Bozen-Bolzano for financial support.

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1 Introduction

The standard model of optimal deterrence advances some well-known predictions on the impact of judicial errors of both types (wrongful convictions and wrongful acquittals) on deterrence. The model shows that they are both detrimental to deterrence and - more interestingly for us - that they are both equally costly in terms of lost deterrence. Hence, a wise social planner should care about wrongful convictions no more than he cares about wrongful acquittals. This is contrary to the common wisdom, to millennia of legal scholarship and to the actual construction of modern legal procedures, which all seem to hint at the fact that wrongful convictions are much worse mistakes than wrongful acquittals. There are a number of rival explanations of why this is the case. Some of them are collected in the literature review and some new ones are developed in the following sections. We first introduce expected utility. We show that, in the presence of monetary gains from crime, standard risk aversion (derived by decreasing marginal returns of income) makes wrongful convictions at the margin more detrimental to deterrence than wrongful acquittals. We also introduce probability weighting with Rank-Dependent Expected Utility and show that, under the reasonable condition that the distribution of probability of correct acquittal stochastically dominates the distribution of probability of wrongful acquittal, overweighting small probabilities exacerbates the adverse effect of wrongful convictions on deterrence. Then we introduce Loss Aversion (through a simplified version of Cumulative Prospect Theory) and show that, wrongful convictions being entirely in the domain of losses, they bring far more disutility to individuals and thus have a larger detrimental impact to deterrence than wrongful acquittals.

We also look at how emotions play out vis-à-vis crime and conviction. We consider three emotions: a) the guilt borne by the culpable (independent of whether he is correctly convicted or wrongfully acquitted); the shame borne by the convicted (independent of whether he is correctly convicted or wrongfully convicted): and indignation borne by the wrongfully convicted. In the last section we draw some policy implications, the most relevant of which is a robust explanation of why we have different standards of proof for civil vis-à-vis criminal procedures.

2 Literature Review

The trade-off between the two types of error has been known and discussed by lawyers and philosophers for a long time. Courts make recurrent mention of it and this seems to point at the case of a conscious and intentional, albeit not systematized, pursuit of a specific ratio of innocent persons convicted to guilty persons acquitted that is more favorable to the innocent. How much more favorable? While every court and scholar would agree that it is desirable to reduce wrongful conviction, how many more wrongful acquittals are we willing to tolerate in order to achieve this goal? Every American student of law learns by

heart Judge Blackstone's maxim that it is *Better that ten guilty persons escape than that one innocent suffer* (1769). The United States Supreme Court has recalled Blackstone's principle although it has never committed to such a precise number¹. Countless scholars have mentioned a precise number for this trade-off; however, as Volokh (1997) has pointed out, there is a great variety of opinions on what the number should be. Volokh finds mentions of the error trade-off (wrongful convictions/wrongful acquittals) that date back to Genesis² and historically vary at least between 1,000³ and 1⁴. Blackstone's famous maxim asserts that the optimal tradeoff must be greater than 10.⁵ However this is a severe underestimation if compared to, for instance, Benjamin Franklin's figure⁶ and some other wildly inflated numbers mentioned in the literature⁷. Irony aside, the error ratio in its extremely variegated declinations expresses the principle that it is better that *in dubio pro reo*. Another way of making this point is to argue, as Posner (1999) does, that the costs of convicting the innocent far exceed the benefits of convicting one more guilty individual and this may be due to a number of reasons.

So why is the maxim that gives this paper its title puzzling for law & economics? Becker (1968) kicked off the economic analysis of crime deterrence arguing *inter alia* that in order to achieve optimal deterrence, wrongful acquittals (that is to say undetected crimes) should be compensated by higher sanctions. Harris (1970) extended the model to consider wrongful convictions also. However, Png (1986) was the first to show the detrimental effects of wrongful convictions on deterrence. His argument runs thus: wrongful acquittals increase the payoff of engaging in the unlawful activity whereas wrongful convictions decrease the payoff of not committing the unlawful act. The result in relative terms is the same, as the gulf between the returns from committing and not committing the crime becomes larger and thus deterrence decreases. Both errors are equally bad to deterrence and cost the same to society. Since then this extension has been incorporated in the main surveys of the subject (See Kaplow, 1994; Garoupa, 1997; Polinsky and Shavell, 2008).

¹The Supreme Court cited Blackstone in "Coffin v. U.S.", 156 U.S. 432 (1895). For direct mention of the trade-off see for instance "Herny v. United States" 61 U.S. 98 (1859): "It is better, so the Fourth Amendment teaches, that the guilty sometimes go free than that citizens be subject to easy arrest", or the concurrent opinion of Judge Harlan in "In re Winship" 397 U.S. 358 (1970) where he states: "I view the requirement of proof beyond a reasonable doubt in a criminal case as bottomed on a fundamental value determination of our society that it is far worse to convict an innocent man than to let a guilty man go free".

²Judge Blackstone's quotation in the title is a reference to Genesis 18:23-32.

³Moses Maimonides, a Jewish Spanish legal theorist, interpreting the commandments of Exodus. Cited in Volokh (1997).

⁴Justinian's Digest. 48.19.5pr. (Ulpianus 7 de off. procons.) sed nec de suspicionibus debere aliquem damnari divus traianus adsidio severo rescripsit: satius enim esse impunitum relinqui facinus nocentis quam innocentem damnari. Also cited in Volokh (1997).

⁵*it is better that ten guilty persons escape, than that one innocent suffer* (Blackstone, 1769).

⁶"it is better [one hundred] guilty Persons should escape than that one innocent Person should suffer". Letter from Benjamin Franklin to Benjamin Vaughan (Mar. 14, 1785), in Franklin and Smyth (1970) cited in Volokh (1997).

⁷See also Reiman and van den Haag (1990).

To dispense with the puzzle, most papers assume that wrongful convictions cost more than wrongful acquittals because of some ethical costs grounded in deontological reasonings: so that convicting the innocent is inherently bad and morally repugnant. Moreover some of these works dispense altogether with the consequences of a high error ratio⁸ on deterrence and consider the optimization of the standard of evidence only in terms of i) expenditure by defendants (Rubinfeld and Sappington, 1987); ii) different fact-finding procedures (Davis, 1994) and technologies (Sanchirico, 1997); and above all iii) the optimization of the exogenously defined moral costs of the two errors (Miceli, 2009). Other authors incorporate deterrence concerns and explain the high standard of evidence in terms of iv) parties' overcompliance (Craswell and Calfee, 1986); v) biased evidence selection (Schrag and Scotchmer, 1994); vi) parties' evidence production expenditure (Yilankaya, 2002); vii) the optimal exercise of care by parties (Demougin and Fluet, 2006); and viii) marginal deterrence (Ognedal, 2005).

Although the standard model claims that the two errors are equally costly in terms of lost deterrence, other papers show that they imply different costs of other kinds. For instance Rizzolli and Saraceno (Forthcoming) elaborate on the costs attached to wrongful convictions by non-monetary sanctions; Lando (2009) add also the ethical costs of both setting the guilty free and of punishing the innocent; Galbiati and Garoupa (2007) introduce the stigma costs of wrongful convictions. Hylton and Khanna (2007) develop a public-choice account of the pro-defendant mechanisms in criminal procedure that affect the error ratio as a set of safeguards against the prosecutor's potential misconduct. In their view the error ratio is the result of a second-best equilibrium achieved within the constraint of an irreducible inclination of prosecutors to over-convict defendants (for various public-choice reasons). Persson and Siven (2007) formulate a general equilibrium model of crime deterrence where the error ratio for capital punishment emerges endogenously as a result of a median voter mechanism applied to the courts. Both models depart from the standard model of deterrence. This paper however shows that, besides all these other explanations, and contrary to the claim of the standard model, wrongful convictions do have an asymmetric impact on deterrence and this is due to some intuitive extensions of the economic model.

3 Production of errors and social welfare

Let us first develop the model under the straightforward assumption of risk neutrality. So let y_0 be the initial endowment (equal for all agents) and b the benefits of committing the crime. b is distributed among the agents with a generic distribution $z(b)$ and a cumulative $Z(b)$ with support $[0, \bar{B}]$. Let also h be the harm/externality generated by the crime.

⁸On the difference between the error ratio and the standard of evidence, see Allen and Pardo (2007); Allen and Laudan (2008).

For the sake of simplicity, all individuals are detected and brought in front of an adjudicative authority⁹. The authority hears the amount of incriminating evidence e that is produced against the defendant and if this overcomes a certain threshold \tilde{e} than the defendant is sentenced to pay the sanction s if punished¹⁰. The evidence is stochastically distributed, albeit that in general more incriminating evidence is available against guilty individuals than against innocent ones. Therefore let e be distributed with $a_i(e)$ for the innocent and with $a_g(e)$ for the guilty where the i subscript stands for innocent and the g stands for guilty. Let $A_i(e)$ and $A_g(e)$ be the cumulative distributions of $a_i(e)$ and $a_g(e)$ respectively and note that $A_i(\tilde{e})$ and $A_g(\tilde{e})$ are the probabilities of being acquitted for the innocent and for the guilty respectively given the threshold evidence level \tilde{e} .

Note also that A_g is the probability of erroneous acquittal of the guilty and $1 - A_i$ is the probability of erroneous conviction of the innocent. Note that, if the level of evidence necessary to reach the conviction \tilde{e} is the main policy variable (the social planner can impose different burdens of evidence), then an increase in \tilde{e} generates both an increase in the number of wrongful acquittals and a decrease in the number of wrongful convictions.

Assumption 1. $A_i(e) > A_g(e) \forall e \in]0, e_{max}[$. Or $A_i(\tilde{e})$ first order stochastically dominates $A_g(\tilde{e})$

This assumption simply imposes that on average, there is more likelihood of accumulating enough evidence to reach a verdict of guilt when the defendant is actually guilty than when the defendant is innocent. If this were not the case and evidence were produced randomly for the innocent and guilty alike, then the whole criminal procedure aimed at distinguishing guilt from innocence makes no sense at all.

⁹Adding here a police agency that could detect crime with some p probability of detection would not change the results as long as the detection was random. See also Mookherjee and Png (1992). See further discussion of this point in Rizzolli and Saraceno (Forthcoming).

¹⁰For the sake of our argument we here assume that the sanction is monetary. Adding non-monetary sanctions would strengthen our point along the lines of Rizzolli and Saraceno (Forthcoming)

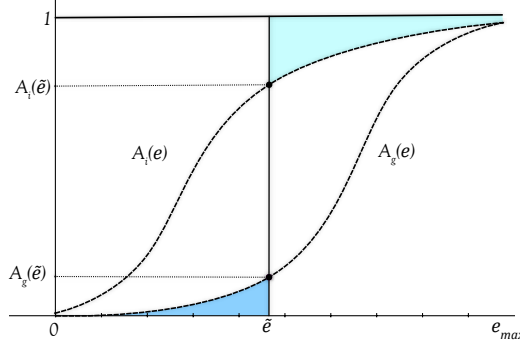


Figure 1: Cumulative distribution of the probabilities of acquittals under the assumption of fofd

Definition 1. Deterrence condition. *The individual does not commit the crime as long as the returns/utility from the criminal activity are below the expected returns/utility of refraining from committing the crime.*

Definition 2. The crime trigger. *Define \tilde{b} as the level of gains from crime above which the deterrence condition does not hold and therefore that triggers the commission of crime.*

For the sake of simplicity, we also assume that there is no welfare-improving crime as in Becker (this would be a crime for which $b > h$).¹¹ In the function of social costs we do not consider the private benefits from crime but only its social costs. Therefore social welfare is

$$SW = \int_{\tilde{b}}^{\bar{B}} z(b) h db \quad (1)$$

or simply $(1 - Z(\tilde{b}))h$. The social welfare boils down to the social costs of harm caused by those individuals for which the deterrence condition is not met. This will be the same for all the subsequent extensions we will illustrate. The amount of social harm ultimately depends on the crime rate $(1 - Z(\tilde{b}))$ and therefore on \tilde{b} . However, the value of \tilde{b} depends on the behavioral assumptions we make concerning the individual choice to commit crime.

Therefore the social welfare function described by Equation 1 will not change in the remaining of the paper; but we will show how different assumptions lead to different values of the crime trigger \tilde{b} and in particular, we will show how the equilibrium of errors will affect the level of \tilde{b} . The purpose of the paper is to explore the conditions for which an error tradeoff which favors fewer wrongful convictions, even at the cost of more wrongful acquittals, is welfare-enhancing.

¹¹See further discussion of this point in ?, Footnote 11.

3.1 Error tradeoff under risk neutrality

Each agent decides whether to stay honest or to commit the crime based on its own returns as follows:

$$\begin{cases} E\pi_i = y_0 - (1 - A_i)s \\ E\pi_g = y_0 + b - (1 - A_g)s \end{cases} \quad (2)$$

The deterrence condition for Equation 2 is satisfied if $E\pi_i \geq E\pi_g$. From this equation we derive the crime trigger, that is to say the benefit threshold above which the individual will commit the crime:

$$\tilde{b} = (1 - (1 - A_i) - A_g) s \quad (3)$$

Proposition 1. *Under risk neutrality wrongful convictions $(1 - A_i)$ and wrongful acquittals (A_g) have the same detrimental impact on the crime trigger and thus on the deterrence condition.*

Note that any change in either wrongful convictions $(1 - A_i)$ or wrongful acquittals (A_g) have the same symmetric impact on deterrence. An equal increase of both determines an equal decrease of \tilde{b} and thus more social costs from crime. This is because on one hand wrongful acquittals undermine deterrence inasmuch as they decrease the probability of guilty individuals being finally convicted. On the other hand wrongful convictions increase the costs of staying honest and thus decrease the relative costs of committing the crime (Png, 1986). With risk neutrality, in terms of deterrence, one further innocent person convicted is as costly as one further guilty person acquitted. This is where the standard model of deterrence stops (Polinsky and Shavell, 2007, section 15, where they elaborate only the risk-neutral case)

Proposition 2. *The optimal standard of evidence \tilde{e} that minimizes social costs is implicitly defined by $a_i(\tilde{e}) = a_g(\tilde{e})$*

Now that the crime trigger is defined, we can plug it into Equation 1 and thus derive the social welfare with respect to the standard of evidence.

$$\frac{\partial SW}{\partial e} = \partial \left(1 - Z(\tilde{b}) \right) h = -z(\tilde{b}) (a_i(\tilde{e}) - a_g(\tilde{e})) s h \quad (4)$$

Under risk neutrality, social costs are minimized when $a_i(\tilde{e}) = a_g(\tilde{e})$. By looking at Equation 3, a “deterrence effect” *à la* Becker (1968) can be identified. Note that \tilde{b} increases with the sanction ($\uparrow s \Rightarrow \uparrow \tilde{b}$). Furthermore an “under-deterrence effect” of judicial acquittals of guilty individuals can be observed: \tilde{b} decreases when the probability of mistaken acquittal increases ($\uparrow A_g \Rightarrow \downarrow \tilde{b}$). Similarly a “compliance effect” of wrongful convictions is identifiable, because \tilde{b} increases when correct punishment increases - and thus wrongful convictions decrease ($\uparrow A_i \Rightarrow \uparrow \tilde{b}$). Finally, a “screening effect” can be established. Let us

define $\Delta(\tilde{e}) = A_i(\tilde{e}) - A_g(\tilde{e})$. $\Delta(\tilde{e})$ represents the ability of the court to distinguish innocent from guilty individuals: the better the court can discriminate, the greater the advantages of staying honest ($\uparrow \Delta(\cdot) \Rightarrow \uparrow \tilde{b}$). This ability reaches its maximum when $a_i(\tilde{e}) = a_g(\tilde{e})$ where the distance $A_i(\tilde{e}) - A_g(\tilde{e})$ is maximized and the sum of the two errors is minimal.

3.2 Error tradeoff under expected utility

Now let us introduce expected utility and risk aversion. Expected utility in the deterrence framework has been considered by Polinsky and Shavell (1979); Dacey and Gallant (1997); Dhimi and al Nowaihi (2010). However, they did not consider wrongful convictions in their models. We have to distinguish two cases:

- The gains from crime have a monetary nature (as in case of theft or robbery) and therefore are subject to decreasing marginal returns of income.
- The gains from crime have a non-monetary nature (such as in case of homicide or rape)

3.3 Monetary gains from crime

We consider b as an amount of money to be gained from committing the crime and from which utility $U(\cdot)$ can be derived. The utility of the action choices available (staying law-abiding or committing crime) are respectively the following

$$\begin{cases} EU_i = A_i U(y_0) + (1 - A_i) U(y_0 - s) \\ EU_g = A_g U(y_0 + b) + (1 - A_g) U(y_0 + b - s) \end{cases} \quad (5)$$

The deterrence condition imposes that $EU(y)_i \leq EU(y)_g$. Rearranging Equation 5 we obtain:

$$\begin{aligned} A_i [U(y_0) - U(y_0 - s)] - A_g [U(y_0 + b) - U(y_0 + b - s)] \\ \geq U(y_0 + b - s) - U(y_0 - s) \end{aligned} \quad (6)$$

which implicitly defines the crime triggers \tilde{b} once we impose $EU(y)_i = EU(y)_g$.

Proposition 3. *Under expected utility, when the gains from crime have a monetary nature, wrongful convictions $(1 - A_i)$ are more detrimental to the deterrence condition than wrongful acquittals (A_g) .*

Equation 6 shows that both $1 - A_i$ and A_g jeopardize deterrence as before.

This is because when there is an increase in either of the errors (increase in A_g or decrease in A_i) on the left-hand side of the equation, individuals find

crime convenient for lower levels of b (on the right-hand side). However, given the concavity of the utility function, the negative impact of wrongful convictions ($1 - A_i$) is stronger than that of wrongful acquittals (A_g). To see why, note that $U(y_0) - U(y_0 - s) > U(y_0 + b) - U(y_0 + b - s)$. In order to maintain the same level of deterrence, a given percentage increase of $1 - A_i$ must be compensated by a smaller percentage decrease of A_g .

In Appendix 7.1 we compute the difference in utility of the two errors as the risk premium calculated with the Arrow-Pratt Absolute Risk Aversion.

3.4 Non-monetary gains from crime

When the gains from crime do not have a monetary nature, the results are very similar to those in Proposition 1.

The utility of the action choices available (staying law-abiding or committing crime) are respectively the following:

$$\begin{cases} EU_i = A_i U(y_0) + (1 - A_i) U(y_0 - s) \\ EU_g = A_g U(y_0) + (1 - A_g) U(y_0 - s) + b \end{cases}$$

The deterrence condition imposes that $EU(y)_i \leq EU(y)_g$. This produces a definition of the crime trigger as follows:

$$\tilde{b} = (A_i - A_g) [U(y_0) - U(y_0 - s)] \quad (7)$$

The individual will commit the crime as long as his non-monetary gain from crime is higher than the net disutility of the sanction discounted by both judicial errors.

Proposition 4. *Under expected utility, when the gains from crime are non-monetary, wrongful convictions and wrongful acquittals are equally detrimental to the deterrence condition.*

From now on we proceed considering only non-monetary gains from crime.

4 Judicial errors and non-expected utility

There exists a vast literature showing that risk aversion derived from the expected utility framework has failed to account for a large amount of field data evidence and experimental evidence (Kahneman, 2003; Kahneman et al., 1990). One important violation concerns the stylized fact that individuals tend to overweight low-probability events such as winning the lottery, or suffering a disastrous insurable loss.

One further important violation concerns people's tendency to strongly prefer avoiding losses to acquiring gains. This behavioral trait is universally known as loss aversion (Kahneman et al., 1991). Expected utility cannot explain this

behavior as it predicts that individuals should objectively weight low probabilities and should only care about absolute payoffs. A number of “non-linear expected utility theories” have emerged to overcome the shortcomings of expected utility. The goal here is to see whether these non-linear expected utility theories are able to explain the high distaste for wrongful convictions observed in the field. In order to use non-linear probability weighting to explain the Becker paradox, one is immediately confronted by a huge literature. Of course we here intend only to use the machinery developed elsewhere and apply it to the issue we care about. For a good review of the different non-expected utility theories, see Dhami and al Nowaihi (2010); al Nowaihi and Dhami (2010) .

4.1 Non linear probability weighting and Rank-Dependent Expected Utility

One first conservative extension of expected utility framework is provided by Quiggin (1982, 1993) with his Rank Dependent expected Utility (RDU). With RDU we can address whether individuals’ tendency to overweight small probabilities has anything to do with the supposedly low probability of wrongful conviction (vis-à-vis wrongful acquittals).

Suppose that the individual choices can be described via RDU. Define w as the probability weighting function¹² and let us also assume that the weighting function is the same for the events in the action spaces of both innocent and guilty individuals. Following Quiggin (1982, 1993) and Dhami and al Nowaihi (2010, Definition 12) and considering the lottery $(x_1, x_2, \dots, x_n; p_1, p_2, \dots, p_n)$ that pays x_i with probability p_i , where $x_1 < x_2 < \dots < x_n$. Define the decision weights under RDU, $\pi_j = w(\sum_{j=i}^n p_j) - w(\sum_{j=i+1}^n p_j)$ where $w(\cdot)$ is a probability weighting function (more on this later) and thus the decision maker’s RDU is $U(x_1, x_2, \dots, x_n; p_1, p_2, \dots, p_n) = \sum_{j=1}^n \pi_j u(x_j)$.

We obtain the result that the two choices of action have the following prospects:

$$\begin{cases} RDU_i = w(A_i)U(y_0) + (1 - w(A_i))U(y_0 - s) \\ RDU_g = w(A_g)[U(y_0) + b] + (1 - w(A_g))[U(y_0 - s) + b] \end{cases}$$

Imposing the deterrence condition leads to the following definition of the crime trigger:

$$\tilde{b} = (w(A_i) - w(A_g)) [U(y_0) - U(y_0 - s)] \quad (8)$$

Equation 8 is very similar to Equation 7 except for the fact that now both probabilities of error are weighted by $w(\cdot)$ which implies that for small probabilities of acquittals $w(A_i) > A_i$ and $w(A_g) > A_g$ while for large probabilities of

¹²Under RDU, infinitesimal probabilities of events are infinitely over-weighted, such that $\lim_{p \rightarrow 0} \frac{w(p)}{p^\gamma} = \infty$ for all $\gamma > 0$. See Definition 9 in Dhami and al Nowaihi (2010).

acquittals $w(A_i) < A_i$ and $w(A_g) < A_g$. The following graph illustrates the curvature of the probability weighting function as used in Tversky and Kahneman (1992).

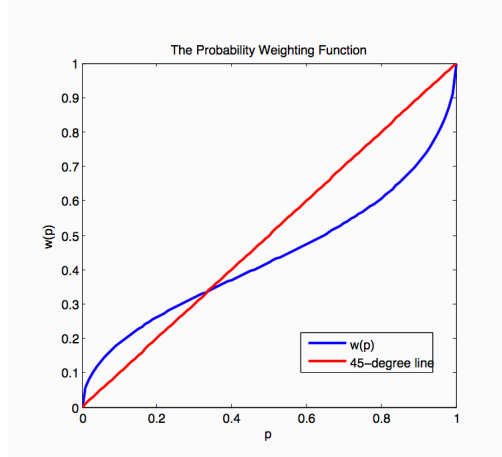


Figure 2: The functional form used by Tversky and Kahneman (1992) with $w(p) = \frac{p^\gamma}{[p^\gamma + (1-p)^\gamma]^{\frac{1}{\gamma}}}$ with $\gamma = 0.61$

To see how RDU affects the deterrence condition, the crime trigger \tilde{b} and the balance of errors we start by recalling Assumption 1, which imposes that $A_i(e) > A_g(e)$. The individual considers both probabilities of being convicted: $1 - A_i(e)$ when innocent and $1 - A_g(e)$ when guilty. For the relatively high level of evidence \tilde{e} required to reach a guilty verdict we know that the probabilities of both wrongful and correct convictions are low and therefore are overweighted because of rank dependent expected utility. However because of the assumption of first order stochastic dominance, it must be true that $1 - A_i(e) < 1 - A_g(e)$ and therefore wrongful convictions are relatively more overweighted than correct convictions. The intuition is the following: for high levels of \tilde{e} , because of RDU people may tend to overweight the low probability of being wrongfully punished and relatively underweight the higher probability of being correctly punished. If people follow RDU, then an objective decrease in $1 - A_i$ (which implies a correspondent albeit lower increase in A_g) may imply a severe deterioration of deterrence. In fact, on one hand, the objective probability $(1 - A_i)$ of wrongful conviction decreases but this effect is partly offset by the fact that smaller probabilities become increasingly overweighted. On the other hand, the decrease in wrongful convictions brings in more wrongful acquittals and, because of the fofd assumption, the effect of the weighting function $w(\cdot)$ on this probability is lower.

Proposition 5. *If individuals overweight small probabilities following RDU, then - ceteris paribus - the deterrence condition deteriorates because the detri-*

mental effect of wrongful convictions $(1 - A_i)$ is relatively more weighted than the beneficial effect of correct convictions $(1 - A_g)$.

4.2 Loss aversion and judicial errors

Another interesting extension concerns the introduction of loss aversion, which is the other major departure from the expected utility framework. In fact people tend to think of possible outcomes of a choice under uncertainty relative to a certain reference point rather than to the final status. As such the observed tendency is for people to prefer the avoidance of losses (outcomes below the reference point) than the acquisition of comparable gains (outcomes above the reference point). Loss aversion is a behavioral concept defined entirely in terms of preferences. Cumulative prospect theory (CPT) accounts for loss aversion and also for the previously mentioned behavioral regularity of over-weighting extreme, but unlikely events and the reflection effect¹³(Bowles, 2004).

We assume that the reference income for both choices is $y_r = y_0$ which is the default income without crime and errors. We choose a y_r such that, if the individual commits the crime and he is punished, he is in the domain of losses ($y_0 - y_g + b - s = b - s < 0$) while if he is not punished, then he is in the domain of gains ($y_0 - y_g + b = b > 0$). We follow mainly the definitions (14,15,16) of Dhami and al Nowaihi (2010). A fully-fledged CPT function would envisage some probability weights as in the case of RDU. For our purposes, however, we are interested in the role of loss aversion in isolation of probability weighting. We adopt the Tversky and Kahneman (1992) utility function with the simplification in the exponent introduced by al Nowaihi et al. (2008)¹⁴ :

$$V(arg) = \begin{cases} (arg)^\gamma & \text{if } (arg) \geq 0 \\ -\theta(-arg)^\gamma & \text{if } (arg) < 0 \end{cases}$$

with coefficients $0 < \gamma < 1$ and $\theta > 1$ ¹⁵

Keeping aside probability weighting, the value functions for the action choices available (staying law-abiding or committing crime) are respectively the following:

$$\begin{cases} V_i = -(1 - A_i)\theta(-s)^\gamma \\ V_g = A_g b - (1 - A_g)\theta[(-s)^\gamma + b] \end{cases}$$

¹³Kahneman and Tversky (1979) observed that when decision problems involve not just possible gains, but also possible losses, people's preferences regarding negative prospects are usually a mirror image of their preferences regarding positive prospects. Simply put, while they are risk-averse over prospects involving gains, people become risk-loving over prospects involving losses. This observation is reflected in the convexity of the value function in the losses.

¹⁴al Nowaihi et al. (2008) show that preference homogeneity and loss aversion are necessary and sufficient for the value function to have the power form with identical powers for gains and losses and for the probability weighting functions for gains and losses to be identical.

¹⁵Tversky and Kahneman (1992) estimated $\gamma \approx 0.88$ and $\theta \approx 2.25$

Note that b stays out of the (arg) because it is not a monetary gain and therefore it is not subject to the exponential utility form. Imposing the deterrence condition leads to the following definition of the crime trigger:

$$\tilde{b} = \left[\frac{A_g - \theta(1 - A_i)}{A_g - \theta(1 - A_g)} - 1 \right] (-s)^\gamma \quad (9)$$

Because of fbsd, $A_g - \theta(1 - A_i) < A_g - \theta(1 - A_g)$ and therefore $\tilde{b} > 0$ as expected. Moreover it is clear that wrongful convictions are more detrimental to the deterrence condition as they enter the equation with the θ weight while wrongful acquittals do not.

Proposition 6. *With loss aversion, wrongful convictions are even more costly than wrongful acquittals and thus detrimental to deterrence.*

5 Judicial errors and emotions

Another set of interesting questions concerns how emotions such as guilt and shame influence the decision to commit crime in particular with regard to the possibility of a wrongful conviction. Behavioral and experimental economics has long considered the impact of guilt and shame on behavior (Elster, 1998; de Hooe et al., 2007; Kurzban et al., 2007; Battigalli and Dufwenberg, 2007b) and law & economics has begun to draw some normative implications from these findings (see McAdams and Rasmusen, 2007; Kaplow and Shavell, 2007 among others, although see Mitchell, 2002 for a critique). Emotions can interact in sophisticated ways with decision-making: they can i) induce hyperbolic discounting of future gains (Loewenstein, 2000); act as “action tendencies”, which ii) shape preferences over actions vis-à-vis outcomes (Elster, 1998) and iii) play a role as “stabilizers” of individuals’ “dispositions to follow rules in the by-presence of opposing situational incentives” (Vanberg, 2008); and iv) be “commitment devices” (Frank, 1988). The modeling of emotions in economic theory is often simplified so as to include emotions as additional (psychological) costs or benefits in the utility function. Emotional costs and benefits enter along with material rewards in the decision calculus. In the context of our paper we specifically focus on guilt, shame and indignation as they all three play a relevant role in the presence of judicial errors and wrongful convictions of the innocent. The three emotions apply to different circumstances in accordance with the following table:

		Is the defendant culpable?	
		Y	N
Is the defendant convicted?	Y	(A_g) Shame & Guilt	$(1 - A_i)$ Shame & Indignation
	N	$(1 - A_g)$ Guilt	(A_i)

Table 1: How emotions apply to the different possible outcomes

5.1 Guilt

Guilt arises in a variety of settings. In bilateral relations guilt arises as a consequence of “the infliction of harm, loss, or distress on a relationship partner” (Baumeister et al., 1994). In such contexts guilt creates interesting strategic results (Battigalli and Dufwenberg, 2007a). In public contexts such as our framework, guilt may arise from violating a social norm, from breaking a moral obligation or from committing an offense. It is a cognitive experience that entails emotional costs to the individual and it is usually related to the magnitude of the harm inflicted with the violation. A rational individual with conformist or pro-social preferences thus weighs the costs of guilt in his decision whether to commit crime. Of course guilt may not arise at all in case of a sadist or totally disinhibited individual. Note that the culpable individual suffers guilt independent of whether he is actually punished or not and note also that the innocent defendant wrongfully convicted does not suffer guilt. We thus model the costs of guilt as a function $\psi(h)$ with $\psi', \psi'' > 0$: the intensity of guilt escalates as the crime becomes graver.

The utility of the action choices available (staying law-abiding or committing crime) are respectively the following:

$$\begin{cases} EU_i = A_i U(y_0) + (1 - A_i) U(y_0 - s) \\ EU_g = A_g U(y_0) + (1 - A_g) U(y_0 - s) + b - \psi(h) \end{cases}$$

The deterrence condition leads to the following definition of the crime trigger:

$$\tilde{b} = (A_i - A_g) [U(y_0) - U(y_0 - s)] + \psi(h) \quad (10)$$

Proposition 7. *The emotion of guilt borne by culpable individuals (independent of whether they are convicted) implies a higher crime trigger but does not alter the symmetric impact of errors on the deterrence condition.*

5.2 Shame

Shame is also a powerful emotion (Nussbaum, 2004) that the defendant may suffer when his conviction becomes common knowledge. Shame is both an emotional cost as well as a tangible cost as the defendant’s peers can observe

the conviction and they may impose a vast array of shaming sanctions on the individual. There is a consistent literature on shaming sanctions (Massaro, 1997; Kahan and Posner, 1999; Alon and Alon, 2005; Kahan, 2005-2006). Shaming sanctions are informal costs imposed on the shamed by others when they refuse to deal with and in general when they impose costs on the shamed individuals. Elster (1998) argues that *the material sanctions themselves are best understood as vehicles of the emotion of contempt, which is the direct trigger of shame. When a person refuses to deal with someone who has violated a social norm, the latter may suffer a financial loss. More important, he will see the sanction as a vehicle for the emotions of contempt or disgust, and suffer shame as a result.* Note that shame is suffered both by the guilty as well as the innocent when they are punished; however, it is not suffered by the guilty who escape conviction. We model shame as a cost $\delta(h)$ which is a marginally increasing function of the magnitude of the crime's harm for which the individual is convicted ($\delta', \delta'' > 0$): the graver the crimes are, the more shameful the related convictions are.

The utility of the action choices available (staying law-abiding or committing crime) are respectively the following:

$$\begin{cases} EU_i = A_i U(y_0) + (1 - A_i) [U(y_0 - s) - \delta(h)] \\ EU_g = A_g [U(y_0) - \delta(h)] + (1 - A_g) U(y_0 - s) + b \end{cases}$$

The deterrence condition leads to the following definition of the crime trigger:

$$\tilde{b} = (A_i - A_g) [U(y_0) - U(y_0 - s)] - (1 - A_i) \delta(h) + A_g \delta(h) \quad (11)$$

Proposition 8. *The emotion of shame borne by convicted individuals implies a higher crime trigger, while shame imposed on innocent ones reduces it. Given the assumption 1, at the margin, shame increases the crime trigger and thus the deterrence condition.*

5.3 Indignation

Indignation is an emotion of annoyance or strong displeasure provoked by what is perceived as unfair, unjust, offensive, insulting, or base treatment (Elster, 1998). It is also referred to as righteous anger and this offers a glimpse of why indignation arises in the context of wrongful convictions of innocent individuals. We can model indignation as an emotional cost that arises in the presence of wrongful convictions and it is borne by the innocent unjustly convicted. Define $\phi(h)$ as the cost of indignation and assume $\phi', \phi'' > 0$.

The utility of the action choices available (staying law-abiding or committing crime) are respectively the following:

$$\begin{cases} EU_i = A_i U(y_0) + (1 - A_i) [U(y_0 - s) - \phi(h)] \\ EU_g = A_g U(y_0) + (1 - A_g) U(y_0 - s) + b \end{cases}$$

Imposing the deterrence condition leads to the following definition of the crime trigger:

$$\begin{aligned} \tilde{b} = & U(y_0) - U(y_0 - s) \\ & - (1 - A_i) [U(y_0) - U(y_0 - s) + \phi(h)] - A_g [U(y_0) - U(y_0 - s)] \quad (12) \end{aligned}$$

Proposition 9. *The emotion of indignation borne by innocent individuals wrongfully convicted implies a lower crime trigger. Moreover wrongful convictions have a larger detrimental impact on the crime trigger than wrongful acquittals.*

6 Some theoretical implications

We have so far established from a theoretical point of view that wrongful convictions bring more disutility than wrongful acquittals under the hypothesis that individuals are risk-averse under both expected and non-expected utility. Why does this matter? We believe that the risk preference explanation of the error bias brings important explanatory implications in at least one respect: it gives a simple intuition of why we have a different burden of proof between civil law and criminal law.

6.1 The burden of evidence in criminal vs civil law explained by risk preferences

The burden of evidence - our \tilde{e} - notoriously differs between different branches of the law. With a great degree of simplification we can argue that it is common to find different specifications of the standard of evidence, increasing in their \tilde{e} , as follows: i) *preponderance of evidence* (POE) used in civil law; ii) *clear and convincing evidence* (CCE) used instead in administrative law; and iii) *beyond any reasonable doubt* (BARD) in criminal law. The burden of proof required under each standard increases as follows: $\tilde{e}_{POE} < \tilde{e}_{CCE} < \tilde{e}_{BARD}$. On one hand we have the POE standard for which a slight prevalence of incriminating over exculpatory evidence can lead to the establishment of guilt by the adjudicative body. On the other hand the BARD standard instead implies that a great amount of evidence must be accumulated before conviction can be reached. The CCE lies somewhere in between. Notoriously the POE standard minimizes the sum of errors (wrongful convictions and wrongful acquittals) while the BARD achieves a low tradeoff of wrongful convictions against wrongful acquittals. Moreover, the BARD standard is often defined in terms of the error ratio that it can achieve and the $1/10$ ratio is considered a reasonable measure. This is sometimes called the Blackstone error ratio after Judge Blackstone's famous maxim: *better that ten guilty escape than that one innocent suffer*.¹⁶

Why do we have these different burdens of proof in different branches of the law? To be sure, there are several rival explanations (Png, 1986; Rubinfeld

¹⁶On the error ratio, see additionally all the literature of previous papers and also a note of caution as explained by Allen and Pardo (2007); Allen and Laudan (2008).

and Sappington, 1987; Reinganum, 1988; Andreoni, 1991; Miceli, 1991; Schrag and Scotchmer, 1994; Schauer and Zeckhauser, 1996; Posner, 1999; Farmer and Terrell, 2001; Yilankaya, 2002; Demougin and Fluet, 2005, 2006, 2007). However, we believe that risk aversion represents a distinct and novel explanation for it. Risk aversion intended as the decreasing utility of income and derived under the expected-utility framework can be justified only over risks involving large amounts of wealth implying a significant change in expected lifetime income. Rabin and Thaler (2001) give the following example: if an individual is observed to always turn down a 50-50 gamble of losing \$10 or gaining \$11, and if we justify this behavior with standard expected-utility risk aversion, then the same individual also must consistently turn down a gamble where there is a 50 per cent chance of losing \$100 and a 50 per cent chance of winning an infinitely large amount of money. Of course this is an absurd level of risk aversion that makes no sense. Rabin (2000) has developed a theorem to calibrate consistent behavior among small and large bets under standard expected-utility risk aversion¹⁷.

The calibration theorem however tells us something important for our argument. That risk aversion affects behavior is a reasonably sound assumption for relatively large bets (such that the expected income over a lifetime is affected). This is generically the case of criminal cases where large stakes are at risk. Note in fact that even relatively short prison sentences carry a significant amount of stigma which has severe repercussions for lifetime earnings because of the psychological costs and the opportunity costs of the prison term, but also because the job-market opportunities are severely undercut (Funk, 2004). If this is true, then for criminal cases it makes sense to increase the burden of evidence in order to spare individuals from the risk of being wrongfully convicted which - as we have seen before - is the most expensive outcome in terms of utility that can happen to an individual. In other words, minimizing the social costs of crime implies minimizing the costs of errors (by moving \tilde{e}) and this in turn implies over-weighting wrongful convictions vis-à-vis wrongful acquittals because these are the most costly errors for the individual.

Conversely, civil cases often involve negligible amounts (at least with respect to income over a lifetime) and a good financial and insurance market can prevent and smooth most of these risks (note moreover that while it is generally possible to insure against losses in civil cases, this is generally ruled out in criminal cases). Therefore the assumption of standard utility risk aversion makes less sense in civil law. The minimization of the social costs - where the costs of wrongful convictions and wrongful acquittals are the same for deterrence - implies a smaller burden of proof.

¹⁷Of course the behaviors observed above can be justified instead under non-expected utility

7 Appendix

7.1 The risk premium calculated with the Arrow-Pratt Absolute Risk Aversion

For an individual willing to take an uncertain bet, the **risk premium** $R(y)$ is defined as the minimum difference between the expected value of a bet and the certainty equivalent he is indifferent to. The **certainty equivalent** $CE(y)$ is the guaranteed payoff at which a person is "indifferent" between accepting the guaranteed payoff and a higher but uncertain payoff. Therefore $R(y) = U[E(y)] - CE[U(y)]$ (that is, the amount of the higher payout minus the risk premium). Because of the Jensen inequality we know that $U[E(y)] \leq E[U(y)]$, which implies the concavity of the utility function.

We also know that the Arrow-Pratt measure of absolute risk aversion (ARA) is $A(y) = \frac{U''(y)}{U'(y)}$ and that risk premium and the Arrow-Pratt ARA measure are linked in the following way (see Cvitanic and Zapatero (2004, pg 112) and also Garoupa (1997)):

$$R(y) = E(y) - CE(y) \approx \frac{1}{2} ARA(\pi) Var[w]$$

where $ARA(\pi)$ is the Arrow-Pratt ARA measure evaluated at the expected income (π) level for the choice of action and $Var[w]$ is the measure of the variance for the given choice of action. We use this to compute thus the risk premium of both staying within the law or committing the crime.

$$\begin{cases} R_i = \frac{1}{2} ARA(y_0 - s) A_i (1 - A_i) s^2 \\ R_g = \frac{1}{2} ARA(y_0 + b - s) A_g (1 - A_g) s^2 \end{cases}$$

and therefore the expected payoffs for staying within the law or committing the crime are:

$$\begin{cases} UE(y)_i \approx y_0 - (1 - A_i)s - \frac{1}{2} ARA(y_0 - s) A_i (1 - A_i) s^2 \\ UE(y)_g \approx y_0 + b - (1 - A_g)s - \frac{1}{2} ARA(y_0 + b - s) A_g (1 - A_g) s^2 \end{cases}$$

Now it is possible to compute the threshold \tilde{b} :

$$\tilde{b} \approx s \left\{ \underbrace{(1 - A_g)}_I \left[\underbrace{1 + \frac{1}{2} ARA(y_0 + b - s) A_g}_II s \right] - \underbrace{(1 - A_i)}_{III} \left[\underbrace{1 + \frac{1}{2} ARA(y_0 - s) A_i}_IV s \right] \right\} \quad (13)$$

where term *I* is the probability of conviction for the guilty defendant, term *II* adds also the risk premium of this option, term *III* is the probability of conviction for the innocent defendant and term *IV* adds also the risk premium for this option. Equation 13 can be also rewritten as $\tilde{b} = (A_i - A_g)s + R_g - R_i$.

The above equation states that the threshold \tilde{b} depends on s and on the capacity of the courts to discriminate between innocent and guilty people, also considering that these two options have a different level of risk.

Now we should use this threshold in computing our social costs.

$$SW = \int_{\tilde{b}}^B R_i - R_g - h z(b) db$$

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