How does the probability of wrongful conviction affect the standard of proof?

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Abstract

The paper inquires into the impact of mistakes of identity (ID) errors on the optimal standard of proof. A mistake of identity is defined as an error such that an individual is punished for someone else's crime; and for the same crime, the criminal is falsely acquitted. Therefore, the decision to engage in a criminal activity generates a negative externality, as the expected number of ID errors increases. Thus, our objective is to understand how public law enforcement can deal with this type of error by means of the standard of proof. Our main results are twofold. First, we show that when ID errors occur, the under-deterrence issue is exacerbated. Second, we find that the optimal standard of proof may be higher or lower than without ID errors, depending on the crime rate at equilibrium and on the impact of the standard of proof on (i) the probability of an acquittal error for each crime committed, (ii) the probability of convicting an innocent person when an acquittal error arises, and (iii) the level of deterrence.

Keywords: Mistakes of identity, standard of proof, deterrence.

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1 Introduction

Motivation. Criminal procedures produce two types of legal errors: wrongful convictions (type 1 errors) and erroneous acquittals (type 2 errors). The probability of each of these errors occuring depends largely on the standard of proof chosen by the law enforcer (*i.e.* the minimum amount of evidence the court/prosecutor has to obtain in order to convict a defendant). Raising the standard of proof makes type 1 errors and type 2 errors more likely. In U.S. criminal courts, the standard of proof currently used is "beyond any reasonable doubt", while in civil law countries judges decide on the basis of their "intime conviction". Both these standards are high, which seems to indicate that more emphasis is placed on avoiding wrongful convictions.

Despite this high standard of proof, errors and notably wrongful convictions still exist. For instance, Risinger (2007) puts the proportion of wrongful convictions in capital murder-rape at between 3.3 and 5%. It is estimated that at least 2.3% of death sentences are wrongful convictions (Gross and O'Brien, 2008). However, public law enforcement theory hardly justifies a high standard of proof. The marginal effect on deterrence of both types of error is assumed to be equal. The issue is even more involved when it comes to blatant crimes (such as capital rape-murder).

Obvious crimes raise new issues regarding the standard of proof (obvious crimes are crimes that leave no room for doubt as to whether they have actually been committed, as is the case with most murders or robberies).[1] In the context of an obvious crime, wrongful convictions are in fact mistakes of identity (ID errors). A mistake of identity is defined as an error such that an individual is punished for someone else's crime; and for the same crime, the criminal is falsely acquitted by the court. This remark seems to plead for a higher standard of proof since ID errors are associated with erroneous acquittals, and are doubly harmful. On the other side, the probability of ID error affects the entire population equally, that

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[1]The answer to the question "was there actually a crime?" is positive and straightforward.

is both the offenders (of another crime) and the non-offenders.[2] Therefore, and as shown by Lando (2006), while erroneous acquittals reduce deterrence, wrongful convictions do not. This provocative result seems to favor lowering the standard of proof for obvious crimes with regard to deterrence concerns. However, we show in our paper that this is not always the case.

Contribution. We assume in our model that an individual's decision to engage in an illegal activity affects the entire population, by raising the probability of being found guilty for someone else's crime.[3] In other words, when committing a crime, an offender generates a negative externality through mistakes of identity (in addition to the classical ones; the harm produced and the expected social cost of imprisonment). We show that ID errors do not affect the deterrence threshold, but rather induce a new legal risk for the entire population.

Furthermore, an important specificity of ID errors is that the probabilities of erroneous acquittal and wrongful convictions are linked. An erroneous acquittal can result from the lack of proof against anyone at all or can be related to a more serious mistake; an innocent person (of this particular crime) is convicted (*i.e.* there are simultaneously a wrongful conviction and a erroneous acquittal).

In this context, raising the standard of proof has three simultaneous effects in our model: (i) increasing the probability of a mistaken acquittal, (ii) decreasing deterrence, and (iii) improving the separation (screening) between acquittal errors and the probability of a mistake of identity (it is more difficult to convict both the true criminal and an innocent person when the standard of proof is higher).

Let us take the example of a bank robbery (Lando, 2006). Assume the crime has obviously happened. The authorities may detect and convict the guilty party (situation 1), or an inno-

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[2]There is a clear distinction between an ID error and a mistake of act: the latter (unlike the former) does not imply that a type 1 error is made, since no crime has necessarily been committed.

[3]Conversely, if no crime has been committed, there are no criminal proceedings and no risk of wrongful convictions.

cent person[4] (situation 2), or may not collect enough evidence against any suspect (situation 3). Imagine the law enforcer decides to increase the standard. If somebody is convicted, it is more probably the guilty party (situation 1). However, raising the standard of proof may raise the probability of not collecting enough evidence against any suspect (situation 3). Moreover, deterrence is diluted (*deterrence effect*) with the consequence that a larger proportion of individuals may decide to take their chance and rob a bank, and there are more type 2 errors for which an ID error is possible (*acquittal effect*). This in turn creates more situations where an innocent person may be wrongfully convicted (situation 2). However, since the amount of evidence required to convict someone is greater, this probability of ID error is lower for a given crime (*screening effect*).

Related literature. This paper is related to the vast law and economics literature on legal errors, deterrence, and the standard of proof.

Since the seminal work of Posner (1973), Png (1986) has shown that erroneous acquittals and wrongful convictions play equal roles on deterrence. However, if this thesis is true and if the social cost of crimes is solely related to the resulting harm, then a type 1 error should be as costly of a type 2 error. As a consequence, the trade-off between the cost of these two kinds of errors should result in an optimal "preponderance of evidence" standard of proof, even in criminal trials. But this argument does not support the existence of a strong bias against type 1 errors (pro-defendant bias) observed in criminal courts regarding the standard of proof ("beyond any reasonable doubt"), when compared to the one used in civil courts ("preponderance of evidence") or in administrative courts ("clear and convincing evidence"). In order to explain these different standards, some authors such as Miceli (1990), Miceli (1991), and Lando (2009) have used fairness arguments to justify a type 1 error being considered more costly than a type 2 error. Setting (exogenously) the cost of a type 1 error higher than the cost of a type 2 error is consistent with the principle laid down by Blackstone (1766): "better that ten guilty persons escape than that one innocent suffer".

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[4]At least of this specific crime.

However, and according to Rizzolli and Saraceno (2013), assuming that the two errors have different weights is tantamount using "*ad hoc* assumptions to the model to adjust for the reality".[5] Several papers have tried to explain this pro-defendant bias endogenously. Among them, Rizzolli and Saraceno (2013) show that the higher social cost of type 1 errors relative to type 2 errors may be explained by the positive costs of punishment. By the same line of argument, Posner (1998) argues that a higher standard of proof is used in criminal trials because imposing a sanction is costlier in this context, relative to the cost of a sanction in civil trials (*e.g.* imprisonment *versus* monetary fines). A second explanation for these different standards comes from Nicita and Rizzolli (2014), who show that the high standard of proof used in criminal courts may be the result of various behavioral hypotheses (such as risk aversion, loss aversion, and non-linear probability weighting). A third explanation comes from Mungan (2011), who shows that the asymmetric costs associated with false convictions and erroneous acquittals may be explained by the choice of non-criminals to engage in costly precautionary activities (or equivalently abstaining from beneficial activities) in order to avoid false convictions, resulting in an increase in the cost of type 1 errors relative to type 2 errors.[6]

Our model provides an additional explanation to the fact that we observe a high standard of proof in criminal courts. However, our explanation rests on the nature of the offense and the relation that exists in this case between a erroneous acquittal and a false conviction. More specifically, we focus on obvious crimes for which a mistake of identity (ID error) may arise: when an individual is punished for someone else's crime, the criminal is falsely acquitted.

In recent years, a debate has emerged over the influence of ID errors on deterrence in the case of obvious crimes such as murders or robberies. In a breakthrough paper, Lando (2006)

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[5]The justification of a higher cost of a type 1 error by appeal to notions of fairness is also problematic if we consider the thesis of Kaplow and Shavell (2001). They suggest that relying on fairness rather than welfare principles to choose public policy may result in a Pareto dominated policy.

[6]This explanation is related to those of Demougin and Fluet (2005) as well as Polinsky and Shavell (1989) in civil disputes, which investigate the ex ante effect of the standard of proof and legal errors on defendant's decisions whether to obey the law.

argues that the view of Png (1986) (erroneous acquittal and wrongful conviction playing an equal role) may be inaccurate since ID errors affect law-abiding and non law-abiding individuals indifferently. This result has been discussed by Garoupa and Rizzolli (2012), who show that ID errors do lower deterrence, since both errors are linked. Lando and Mungan (2016) recently argued that policy changes may, however, affect the different types of error in opposite directions, thus keeping deterrence constant while reducing wrongful convictions.

Most of the papers cited above abstract from the standard of proof. We take the next step by analyzing the effects on the optimal standard of proof in order to answer two questions: (1) How does the probability of an ID error affect the behavior of potential offenders? (2) How does the probability of an ID error impact the optimal standard of proof, and what policy implications can be derived?

Main results. We show that the probability of an ID error has no effect on the deterrence threshold.[7] However, at equilibrium, the existence of ID errors moves the deterrence threshold away from the socially optimal one (because deterrence becomes more desirable). Therefore, the under-deterrence issue already highlighted in the literature is exacerbated.[8] This result holds for any given standard of proof. The rationale behind it is that there exists an additional externality effect of committing crimes: this decision increases the probability of a mistake of identity for the entire population, and as a consequence the costs associated with undeserved punishments.

We also show that the optimal standard of proof is ambiguously affected by the existence of ID errors. The law enforcer faces a trade-off. On the one hand, raising the standard is costly because of two separate effects. First, fewer people are deterred as it is easier to escape the sanction since the judge needs more evidence to convict a criminal (*deterrence effect*). Second, raising the standard of proof decreases the probability of convicting the guilty party.

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[7]As said earlier, this result has already been emphasized by Lando (2006).

[8]See for example Polinsky and Shavell (1992), Garoupa (2001) and Rizzolli and Saraceno (2013).

As a consequence, more type 2 errors are made, increasing the number of crimes for which an ID error may exist (*acquittal effect*). On the other hand, raising the standard of proof may be beneficial by reducing the probability that an ID error is made for each type 2 error (*screening effect*).

Overall, we find that the optimal standard of proof should increase with the probability of ID errors only if the *screening effect* dominates the *deterrence effect* and the *acquittal effect*. We believe this result is a plausible explanation for the higher standard of proof used in criminal courts.

Summary of the paper. The rest of this paper is organized as follows. Section 2 presents the model. In section 3, the optimal standard of proof is derived, and we study the effect of the existence of mistakes of identity on this optimal standard. Finally, section 4 concludes.

2   The model

The basic framework elaborates on the model of law enforcement *à la Becker*.[9] There are two types of players: a benevolent public law enforcer and a continuum of risk-neutral individuals. The benevolent public law enforcer aims at maximizing social welfare by choosing the standard of proof, while each individual must decide whether or not to commit an offense.

The timing is the following. At time $t = 0$, the public law enforcer announces the standard of proof $x \in [0, 1]$. This standard refers to the amount of evidence necessary to convict a suspect, with $x = 0$ (resp. $x = 1$) the minimum (resp. maximum) amount of evidence required. At time $t = 1$, the individuals choose whether or not to commit an offense. Finally, at time $t = 2$, the law is enforced and payoffs are realized.

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[9]Except that we focus on the standard of proof, rather than on the choice of the sanction and the means given to detection, apprehension and conviction. See the surveys by Polinsky and Shavell (2000) and Garoupa (1997).

2.1 Errors

Contrary to the usual *Beckerian* framework, and following Lando (2006), we assume that individuals face a probability of being convicted for someone else's crime. As noticed by Garoupa and Rizzolli (2012), each mistake of identity (demand side) results in a erroneous acquittal (supply side).[10] Therefore, there exists a relation (or constraint) between erroneous acquittals (type 2 errors) and mistakes of identity (ID errors). Here, we consider that erroneous acquittal can result either in the absence of any individual being found guilty, or in the conviction of the wrong person. The constraint is written as:

$$\epsilon_3(x) = \alpha(x) \, n \epsilon_2(x) \tag{1}$$

with $\epsilon_3 \in [0,1]$ the probability that an individual is convicted for someone else's offense, $\epsilon_2 \in [0,1]$ the probability of erroneous acquittal, $n \in [0,1]$ the proportion of criminals (endogenously determined), and $\alpha(x) \in [0,1]$ the probability of an ID error for each acquittal error.[11] Acquittal and ID errors depend on the standard of proof (x). We assume that a higher standard of proof increases the probability of erroneous acquittal as more evidence is required to secure conviction.

Hypothesis 1. $\epsilon_2(x) \geq 0$, $\epsilon_2'(x) \geq 0$.

Furthermore, we assume the relation between erroneous acquittal and identity error is weaker the higher the standard of proof. In other words, the probability of an ID error for each type 2 error decreases with the standard of proof.

Hypothesis 2. $\alpha(x) \geq 0$, $\alpha'(x) \leq 0$.

Note that we are aware that different steps exist in the legal criminal procedure: investigation and adjudication. The process of litigation can reveal wrongful detection by the police. Here we assume that detection is given, and we focus on adjudication.

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[10] Assuming there is only one individual guilty per crime.

[11] Note that, as explained by Rizzolli (2016), "the inverse causation does not necessarily hold, as the acquittal of the perpetrator does not imply the conviction of an innocent person".

2.2 The decision to commit a crime

Individuals consider whether or not to commit an offense which creates a *per capita* external cost $h > 0$. Individuals differ in the benefit $b \in [0, 1]$ they get from a crime. This benefit is distributed in the population according to the density function $f(.)$ and the cumulative distribution $F(.)$ with support $[0, 1]$. There exists an exogenous non-monetary sanction $a > 0$ (such as a term of imprisonment). The marginal cost of the non-monetary sanction for a convicted criminal is normalized to 1. Let us define $n \in [0, 1]$ as the proportion of criminals (*i.e.* undeterred individuals). There exists a positive social cost of imposing the non-monetary sanction a. This cost is financed by a tax t and the financing constraint will be specified later.

Let $w \geq 0$ denote the wealth of individuals. The expected utility of law-abiding individuals is defined as:

$$u_{nc} = w - \epsilon_3(x) a - nh - t \tag{2}$$

The expected utility of individuals who commit the offense, henceforth called "criminals", is defined as:

$$u_c = w + b - (1 - \epsilon_2(x)) a - \epsilon_3(x) a - nh - t \tag{3}$$

An individual decides to commit an offense if:

$$u_c \geq u_{nc} \tag{4}$$

That is if:

$$b \geq (1 - \epsilon_2(x)) a := \hat{b} \tag{5}$$

By normalizing the size of the population to 1, the proportion of individuals deciding to engage in illegal activity is:

$$n = 1 - F\left(\hat{b}\right) \tag{6}$$

2.3 Comparison with the optimal behavior

The law enforcer chooses x in order to maximize the social welfare function under the following financing constraint:

$$t = [(1 - \epsilon_2(x)) n + \epsilon_3(x)] ac_p \tag{7}$$

with $c_p > 0$ the social marginal cost of imprisonment. The social cost of punishing an individual is thus ac_p.[12] The tax t has to cover these imprisonment term expenses for those convicted among the non-compliant (the proportion of which is $(1 - \epsilon_2(x)) n$), plus the expenses for those who are convicted due to a mistake of identity (the proportion of which is $\epsilon_3(x)$).

The social welfare function is defined as the sum of the utility of individuals:

$$SW = F\left(\hat{b}\right) u_{nc} + \int_{\hat{b}}^{1} f(b) u_c db \tag{8}$$

By substituting u_{nc} and u_c in SW, and introducing the constraints on $\epsilon_3(x)$ and t given respectively by (1) and (7), we get:

$$SW = w + \int_{\hat{b}}^{1} f(b) \left[b - [(1 - \epsilon_2(x)) + \alpha(x) \epsilon_2(x)] a(1 + c_p) - h \right] db \tag{9}$$

Let m be the probability that an individual is convicted of each crime committed as a function of the standard of proof (x):

$$m(x) = (1 - \epsilon_2(x)) + \alpha(x) \epsilon_2(x) \tag{10}$$

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[12] By comparison, the private cost incurred by the individual found guilty is a.

Substituting $m(x)$, SW can be rewritten as:

$$SW = w + \int_{\hat{b}}^{1} f(b) \left[b - m(x) a (1 + c_p) - h \right] db \tag{11}$$

Let us now characterize the socially optimal behavior b_o of individuals, as a matter of comparison with the threshold $\hat{b}$ defined by (5). By substituting b_o for $\hat{b}$ in (11) and differentiating SW with respect to b_o, we obtain:

$$\frac{\partial SW}{\partial b_o} = 0 \iff b_o = m(x) a (1 + c_p) + h \tag{12}$$

Recall that $\hat{b} = (1 - \epsilon_2(x)) a$. The difference between the socially optimal behavior b_o and $\hat{b}$ is given by:

$$b_o - \hat{b} = \alpha(x) \epsilon_2(x) a (1 + c_p) + (1 - \epsilon_2(x)) a c_p + h := \Delta b > 0 \tag{13}$$

In other words, too many crimes are committed at the equilibrium by comparison with the social optimum, since $b_o > \hat{b}$.

Proposition 1. *At equilibrium, too many crimes are committed by comparison with the social optimum.*

Proof. The proof is in the text. $\qquad \square$

This result can be explained by three effects. The first two are classical ones, found in the literature and showing that there is under-deterrence: an individual who commits a crime (i) generates an external harm which diminishes the utility of the entire population and (ii) disregards the effect of his decision on the increase of tax for the entire population when his crime results in a conviction. The third effect is due to mistakes of identity and exacerbates the under-deterrence issue: an individual who commits a crime imposes another negative externality by increasing the probability of ID errors, and thus by increasing the social costs associated with this error, through both tax and the loss of utility of the person convicted.

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This result holds whatever the standard of proof (x). Therefore, the standard of proof chosen by the public law enforcer is necessarily a second best optimum.

3 Public policy implications

In this section, our aim is first to determine the law enforcer's optimal choice regarding the standard of proof, and second to study how mistakes of identity impact this optimal standard.

3.1 The optimal standard of proof

Recall that the sum of the utilities of individuals defines social welfare, which is given by (11). The standard of proof affects social welfare through (i) the level of deterrence, which is given by $\hat{b}$ and is a function of x, and (ii) the probability of a crime resulting in a conviction (whether or not a mistake of identity is committed), through the function m.

3.1.1 Deterrence threshold

First, we study the effect of an increase in the standard of proof (x) on deterrence (the threshold $\hat{b}$). We have:

$$\frac{\partial \hat{b}}{\partial x} = -\epsilon_2'(x) \, a < 0 \tag{14}$$

When the standard of proof increases, the probability of an acquittal error increases ($\epsilon_1'(x) > 0$). Accordingly, the expected punishment for the criminal (*i.e.* the price of committing a crime) decreases, and thus the number of crimes increases. This results in a decrease in social welfare since the number of crimes is already higher than the optimal level (see proposition 1).

3.1.2 Probability of conviction

Second, we study the effect of an increase in the standard of proof on the probability of a conviction when a crime is committed $(m(x))$. We can show that this probability is

decreasing:

$$\frac{\partial m}{\partial x} = \alpha'(x)\,\epsilon_2(x) - \epsilon_2'(x)\,(1 - \alpha(x)) < 0 \tag{15}$$

An increase in the standard of proof has two separate effects. First, the number of acquittal errors increases (a criminal is less likely to be convicted of committing his own crime). Second, the probability with which an acquittal error leads to an ID error decreases ($\alpha'(x) < 0$). Both these effects contribute to reducing the probability of a conviction for each offense committed.

3.1.3   Social welfare

Finally, the derivative of social welfare function SW with respect to the value of the standard of proof (x) is:

$$\frac{\partial SW}{\partial x} = -\frac{\partial m}{\partial x}\left(1 - F\left(\hat{b}\right)\right) a\,(1 + c_p) - \frac{\partial \hat{b}}{\partial x} f\left(\hat{b}\right)\left(\hat{b} - m(x)\,a\,(1 + c_p) - h\right) \tag{16}$$

By rearranging, we obtain the following FOC when there is an interior solution to the optimal choice of the standard of proof:

$$-\frac{\partial m}{\partial x}\left(1 - F\left(\hat{b}\right)\right) a\,(1 + c_p) = -\frac{\partial \hat{b}}{\partial x} f\left(\hat{b}\right) \Delta b \tag{17}$$

The left-hand side of this equation is the marginal gain of an increase in the standard of proof. This marginal gain stems from the fact that, for each crime committed, the likelihood of a conviction (and thus the costs associated with punishments) decreases as the standard of proof increases. The right-hand side is the marginal cost of an increase in the standard of proof. This marginal cost derives from the fact that when the standard of proof increases, a larger number of individuals decide to commit crimes, while the number of crimes is already above the socially optimal level (see proposition 1). The conditions under which an interior solution x^* for the optimal standard of proof exists are discussed in appendix 5.1. In the rest of our analysis, we assume these conditions are satisfied, because we believe this case to

be the most interesting and most representative when compared to the corner solutions.

3.2   The impact of mistakes of identity

Now that we have characterized the socially optimal behavior of individuals in contrast to their equilibrium behavior (Δb) and the optimal standard of proof chosen by the law enforcer (x^*), our main objective is to lead a comparative static analysis to answer the following question: what is the impact of the possibility of making mistakes of identity on the optimal standard of proof? To provide an answer, we study how the value of the optimal standard of proof varies as the shape of $\alpha(x)$ changes. More specifically, we compare a situation in which there are no ID errors (or ID errors are ignored), to one in which there is a positive probability of ID errors for each type 2 error (or ID errors are aknowledged).

First, we compare the marginal gain from an increase in the standard of proof (the left-hand side of (17)) when we go from a scenario in which the probability of ID errors is ignored (scenario 1) to a scenario in which the law enforcer aknowledges the possibility of ID errors when he chooses the standard of proof (scenario 2), with x' (resp. x^*) the optimal standard of proof in scenario 1 (resp. scenario 2).[13] The variation in the marginal social gain from an increase in the standard of proof when we switch from scenario 1 to scenario 2 is:

$$ - \left[\alpha'\left(x'\right)\epsilon_2\left(x'\right) + \alpha\left(x'\right)\right]\left(1 - F\left(\hat{b}\right)\right) a\left(1 + c_p\right) < 0 \tag{18} $$

Similarly, the variation in the marginal social cost resulting from an increase in the standard of proof is:

$$ - \alpha\left(x'\right)\epsilon_2\left(x'_1\right) \frac{\partial \hat{b}}{\partial x} f\left(\hat{b}\right) \epsilon_2\left(x'\right) a\left(1 + c_p\right) > 0 \tag{19} $$

Thus, there is an increase in the optimal standard of proof (*i.e.* $x^* > x'$) when we switch from scenario 1 to scenario 2 if the marginal gain given by (19) is strictly superior to the

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[13]We assume that there exists a unique interior solution for the optimal standard of proof in each of theses scenarios.

marginal cost given by (18).

Proposition 2. *The optimal standard of proof strictly increases when there exists a strictly positive probability of ID errors $\alpha(x) > 0$ (compared to the scenario in which this probability is $\alpha(x) = 0$) if:*

$$\left| \frac{\alpha'(x')}{\alpha(x')} \right| > \left| \frac{\epsilon_2'(x')}{\epsilon_2(x')} \right| + \left| \frac{\partial \hat{b}}{\partial x} \frac{f(\hat{b})}{n} \right| \tag{20}$$

Proof. Condition (20) ensues directly from comparison of (19) and (18). For a more general proof comparing two scenarios in which the probability of ID errors is strictly positive in each, see appendix 5.2.

□

The intuition behind this proposition is the following. The law enforcer faces a trade-off. On the one hand, when we switch from scenario 1 to scenario 2, the law enforcer benefits from a decrease in the probability of an ID error for each acquittal error when he increases the standard of proof (because $\alpha'(x) < 0$). As a consequence of this new marginal gain, the law enforcer will thus benefit more from an increase in the standard of proof (*screening effect*). On the other hand, this increase in the standard of proof comes at a cost since it will increase the number of type 2 errors (*acquittal effect*), and thus the number of cases for which costly ID errors may arise. Finally, another cost of increasing the standard of proof is that deterrence decreases, since we have $\frac{\partial \hat{b}}{\partial x} < 0$ (*deterrence effect*). We see from (20) that this trade-off does not depend on the value of the external harm (h).

Corollary 1. *Suppose there exists a strictly positive probability of a mistake of identity ($\alpha(x) > 0$). When compared to the situation in which $\alpha(x) = 0$, an increase in the standard of proof may be optimal only if the following necessary condition is satisfied:*

$$\frac{\left| \frac{\alpha'(x')}{\alpha(x)} \right|}{\left| \frac{\epsilon_2'(x')}{\epsilon_2(x)} \right|} > 1 \tag{21}$$

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An increase in the standard of proof is more likely to be socially beneficial if (i) the (negative) effect of the standard of proof on deterrence (and thus the punishment a) is sufficiently high and (ii) the crime rate (n) is sufficiently low.

Proof. The proof is straightforward from proposition 2 and (5). □

Condition (20) implies that for the law enforcer to benefit from an increase in the standard of proof, a necessary condition is that for an increase of 1% of the probability of an acquittal error following an increase in the standard of proof (due to the *acquittal effect*), the decrease in the probability of a mistake of identity, for this same increase in the standard of proof, should be superior to 1% (i.e. the *screening effect* should be strong enough). More specifically, we observe that in order to justify an increase in the standard of proof, the *screening effect* has to outweigh the *acquittal effect* when: (i) the (negative) effect of the standard of proof on deterrence strengthens and (ii) the crime rate at the equilibrium (n) weakens. We believe that this assumption is not a very strong one. Finally, our results suggest that the higher social and private costs of sanctions in criminal courts may justify the use of a higher standard of proof than in civil courts. We have shown that an increase in the standard of proof, once mistakes of identity are acknowledged, is more likely to be socially beneficial if the punishment (a) is severe.

4   Conclusion

In this paper, we investigate the impact of mistakes of identity (ID errors) on individuals' decisions whether or not to commit crimes, and on the law enforcer's choice of the optimal standard of proof.

Our main results are twofold. First, we show that the existence of mistakes of identity tends to exacerbate the standard under-deterrence result already reported in the literature. Second, we characterize the optimal standard of proof, and we show that when the probability of ID mistake per erroneous acquittal (type 2 error) increases, then there exists a trade-off for

the law enforcer when he decides on the optimal standard of proof. On the one hand, increasing the standard of proof reduces the probability of a costly ID error being made for each type 2 error. On the other hand, increasing this standard reduces deterrence and increases the number of cases for which a type 2 error is made and which may be subject to an ID error.

In order to simplify the presentation, we focused in our analysis on obvious crimes, where type 1 errors defined as mistakes on act (convict somebody for an act which has not been committed) are not an issue. A first possible extension of our model may be to introduce errors as to the act. However, we believe that it would increase significantly the complexity of the presentation, without changing the main results. A second possible extension may be to introduce monetary sanctions. However, since a monetary sanction may be considered as a neutral transfer in terms of social welfare, we will then need to find another explanation for the existence of a positive standard of proof (one possible explanation is that the court may commit type 1 errors as to the act, in addition to identity errors).

5 Appendix

5.1 The existence of an interior solution x^*

In this appendix, we ask what the conditions are that allow an interior solution for the choice of x^* to exist? To answer this question, it may be useful to rewrite the FOC given by (17) as follows:

$$\underbrace{\frac{\partial m/\partial x}{\partial \hat{b}/\partial x}}_{E_1} = \underbrace{\frac{f\left(\hat{b}\right)\Delta b}{\left(1 - F\left(\hat{b}\right)\right)a\left(1 + c_p\right)}}_{E_2} \tag{22}$$

Consider first that $E_1 \leq E_2$ for $x = 0$. Then a corner solution such that $x^* = 0$ may exist. More specifically, if for $x = 0$, $|\frac{\partial \hat{b}}{\partial x}|$ is large relative to $|\frac{\partial m}{\partial x}|$, then the (negative) effect on deterrence of an increase in the standard of proof is relatively strong when compared to its (negative) effect on the probability that a crime results in a conviction, even with a minimum value of the standard of proof. Accordingly, an increase in the standard of proof, even when $x = 0$, will have the adverse effect of increasing the number of crimes (and thus of exacerbating the cost of the associated externalities), without consistently decreasing the cost of conviction (which is borne by the convicted individual as disutility from the punishment, and by the rest of society through the funding of the prison service). Consider secondly that $E_1 \geq E_2$ for $x = 1$. Similar reasoning shows that if, for $x = 1$, $|\frac{\partial m}{\partial x}|$ is large relative to $|\frac{\partial \hat{b}}{\partial x}|$, then a corner solution such that $x^* = 1$ may exist.

We can observe that external harm (h) only appears in Δb in (22), and Δb increases with respect to h. Thus, we are always able to find a threshold value of h above which we have $E_2 > E_1$ whatever the standard of proof (x). In this situation, the law enforcer's main objective is deterrence and, as a result, he will choose a minimum standard of proof, with $x^* = 0$, since it allows him to maximize deterrence $(\frac{\partial \hat{b}}{\partial x} < 0)$. However, this result may change if we allow the severity of the punishment to depend on h.

As an illustration, we are able to show that at least one interior solution for the optimal standard of proof always exists if we assume that $\epsilon_2'(x=0)=0$, $\alpha'(x=1)=0$, and h is sufficiently high, because $\frac{\partial WS}{\partial x}$ is continuous for all $x \in [0,1]$, and with these assumptions we always have $\frac{\partial WS}{\partial x}>0$ for $x=0$ and $\frac{\partial WS}{\partial x}<0$ for $x=1$. However, if these assumptions provide sufficient conditions for an internal solution to exist, they are also overly restrictive in our context.

5.2 A more general comparative static analysis on α

We consider two functions α_1 and α_2 such that, for all x, the following conditions are satisfied:

$$\alpha_1(x) < \alpha_2(x) \tag{23}$$

and:

$$\alpha_1'(x) > \alpha_2'(x) \tag{24}$$

These hypotheses mean that when the shape of the function α switches from $\alpha(x) = \alpha_1(x)$ to $\alpha(x) = \alpha_2(x)$ then, all other things remaining constant (including the standard of proof), the number of ID errors is higher. However, when $\alpha(x) = \alpha_2(x)$, the standard of proof may be used more efficiently to screen defendants: a similar increase in x has a bigger impact on the probability of an ID error for each acquittal error (because $\alpha_2'(x) < \alpha_1'(x) < 0$).

The marginal gain from an increase in the standard of proof if the shape of α goes from $\alpha(x) = \alpha_1(x)$ to $\alpha(x) = \alpha_2(x)$ is:

$$- \left[(\alpha_2'(x') - \alpha_1'(x'))\, \epsilon_2(x') + (\alpha_2(x') - \alpha_1(x'))\right] \left(1 - F\left(\hat{b}\right)\right) a\,(1 + c_p) \tag{25}$$

with x' (resp. x^*) the supposedly unique and interior optimal standard of proof if $\alpha(x) = \alpha_1(x)$ (resp. $\alpha(x) = \alpha_2(x)$).

Similarly, The variation in the marginal social cost resulting from an increase in the standard of proof is:

$$- \left[\alpha_2 \left(x' \right) - \alpha_1 \left(x' \right) \right] \epsilon_2 \left(x_1' \right) \frac{\partial \hat{b}}{\partial x} f \left(\hat{b} \right) \epsilon_2 \left(x' \right) a \left(1 + c_p \right) \tag{26}$$

By comparing (26) and (25) and rearranging, we find there is an increase in the optimal standard of proof (*i.e.* $x^* > x'$) if:

$$\left| \frac{\alpha_2' \left(x' \right) - \alpha_1' \left(x' \right)}{\alpha_2 \left(x' \right) - \alpha_1 \left(x' \right)} \right| > \left| \frac{\epsilon_2' \left(x' \right)}{\epsilon_2 \left(x' \right)} \right| + \left| \frac{\partial \hat{b}}{\partial x} \frac{f(\hat{b})}{n} \right| \tag{27}$$

This condition and its interpretation are similar to those given in proposition 2 by (20).

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