



IDENTITY MISTAKES AND THE STANDARD OF PROOF

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Identity mistakes and 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. 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 when ID errors are accounted for, the optimal standard of proof increases when the savings in punishment costs due to ID errors (induced by a lower probability of conviction per crime) exceed the increase in punishment costs (induced by a lower deterrence rate).

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

JEL codes: K4.

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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 occurring depends largely on the standard of proof chosen by the law enforcer (*i.e.* the minimum degree of certainty the court has to reach in order to convict a defendant). Raising the standard of proof makes type 1 errors less likely and type 2 errors more likely. In U.S. criminal courts, the standard of proof currently used is “beyond any reasonable doubt”, while in quasi-civil cases (such as the termination of parental rights or psychiatric internment) judges apply the “clear and convincing evidence” standard, which is still higher than the “preponderance of evidence” standard used in civil cases. The “beyond any reasonable doubt” standard is reached if no other logical explanation can be derived from the facts except that the defendant committed the crime. It is commonly admitted that this standard roughly corresponds to a degree of certainty of 95-99% that the defendant is guilty, while the “clear and convincing evidence” and the “preponderance of evidence” account respectively for 65-75% and 50% degree of certainty (Guerra et al., 2017; Rizzoli, 2016).¹ Such a high level of standard used in criminal cases seems to indicate that more emphasis is placed on avoiding wrongful convictions rather than erroneous acquittals, as individual freedom is at stake.

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).² However, the standard public law enforcement theory, where the two types of error have the same marginal effect on deterrence, hardly justifies a high standard of proof. The issue is even more involved when it comes to offenses

¹In France, there is no standard of proof as such (Leclerc and Vergès, 2015). However, judges and juries refer to the *intime conviction* principle both in civil and criminal cases. This French term of *intime conviction* is also called “full conviction” (Guerra et al., 2017). See also Clermont and Sherwin (2002) and Taruffo (2003).

²See also the estimations of type I and type II errors in criminal cases provided by Spencer (2007).

which have been obviously committed.

Indeed, crimes that leave no room for doubt as to whether they have actually been committed raise new issues regarding the standard of proof. For such crimes, the answer to the question “was there actually an offense?” is positive and straightforward. In the context of such crimes, 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.³ On the other side, the probability of being wrongfully convicted affects the entire population equally, that is both the offenders (of another crime) and the non-offenders. 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. In our paper, we show that, while not affecting the deterrence threshold directly ([Lando, 2006](#)), ID errors induce a new legal risk for the society justifying (under certain conditions) a higher standard of proof.

Contribution. We investigate how ID errors affect the optimal standard of proof when punishment is costly (such as imprisonment). 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.⁴ In other words, when committing a crime, an offender generates a negative externality through mistakes of identity (in addition to the classical externalities: the harm produced and the expected social cost of imprisonment if he is convicted).

³There 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.

⁴Conversely, if no crime has been committed, there are no criminal proceedings and no risk of wrongful convictions.

In this context, raising the standard of proof has two simultaneous effects: (i) decreasing the probability that an individual is convicted for each crime committed (allowing some savings in the expected punishment costs), and (ii) decreasing deterrence (inducing an increase in the expected punishment costs).

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 (case 1), or an innocent person⁵ (case 2), or may not collect enough evidence against any suspect (case 3). In case 3, the criminal procedure can end at the detection, prosecution or conviction level.⁶ Imagine the law enforcer decides to increase the standard. If somebody is convicted, it is more likely to be the guilty party (case 1). However, raising the standard of proof may raise the probability of not collecting enough evidence against any suspect (case 3). Moreover, deterrence is diluted with the consequence that a larger proportion of individuals may decide to take their chance and rob a bank. This in turn creates more situations where an innocent person may be wrongfully convicted (case 2). However, since the amount of evidence required to convict someone is greater, this probability of ID error is lower for a given crime.

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

The standard model of public law enforcement ([Garoupa, 1997](#); [Kaplow, 1994](#); [Polinsky and Shavell, 2000](#)) generally assigns the same marginal impact on deterrence of both wrongful convictions and wrongful acquittal. This common view is generally attributed to [Png \(1986\)](#), and seems to be confirmed by experimental studies ([Rizzolli and Stanca, 2012](#)).⁷ However,

⁵At least of this specific crime.

⁶For instance, the police do not detect any suspect, or prosecution decides not to take the case in court due to lack of evidence, or the judge/jury acquit the suspect due to lack of evidence. Prosecution has to bring the case in court, taking into account the level of the standard of proof. If prosecution expects that the evidence collected does not meet the standard of proof, prosecution might renounce to bring the case in court. The jury might also consider that the evidence collected does not allow to reach the degree of certainty of guiltiness of the suspect required by the standard of proof.

⁷For further discussion, see [Lando and Mungan \(2017\)](#).

if this thesis is true and if the social cost of crimes is solely related to the resulting harm, then both types of errors should be equally costly (Nicita and Rizzolli, 2014; Rizzolli and Saraceno, 2013; Rizzolli, 2016). 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”.⁸

However, and according to Rizzolli and Saraceno (2013), assuming that the two errors have different weights is tantamount to using “*ad hoc* assumptions to the model to adjust for the reality”.⁹ 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 Kaplow (2011a,b) and Mungan (2011), who show that the asymmetric costs associated with

⁸See also the literature review provided in Nicita and Rizzolli (2014).

⁹The 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.

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, or benign acts) in order to avoid false convictions, resulting in an increase in the cost of a type 1 error relatively to the cost of a type 2 error. As explained by [Lando and Mungan \(2017\)](#), this result is related to that of [Craswell and Calfee \(1986\)](#) and [Shavell \(1987\)](#). In presence a of wrongful conviction, the potential defendant may choose a level of care higher than the socially optimal one, reflecting overdeterrence. This result occurs when the choice is no more binary (committing the offense or not) but for instance continuous ([Rizzolli, 2016](#)).

In a context in which punishment is costly for society, our model provides an additional explanation to the fact that we observe a high standard of proof in criminal courts. Our explanation rests on the nature of the offense and the relation that exists in this case between an 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 \(2006\)](#) 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 by an equilibrium constraint between demand and supply of mistakes. [Lando and Mungan \(2017\)](#) recently review the effect of type 1 errors on deterrence, with a focus on ID mistakes.¹⁰ Our paper is closely related to both [Lando \(2006\)](#), [Lando and Mungan \(2017\)](#) and [Garoupa and Rizzolli \(2012\)](#). In our framework, since ID errors affect law-abiding and non law-abiding individuals indifferently, the direct impact of ID mistakes on deterrence is null. However, we assume

¹⁰Note that the authors do not address the issue of the standard of proof in the model in relation to ID mistakes, but mention it (p.5).

that type 2 errors and ID mistake are related, since an ID mistake implies to not prosecute and/or not convict the guilty one.

The contributions cited above generally 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?

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*.¹¹ 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.

¹¹Except 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

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 an erroneous acquittal (supply side).¹² 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 be associated either with the absence of any individual being found guilty, or with the conviction of the wrong person. The constraint is written as:

$$\epsilon_c(x) = \alpha(x) n \epsilon_a(x) \tag{1}$$

with $\epsilon_c \in (0, 1)$ the probability that an individual is convicted for someone else’s offense, $\epsilon_a \in (0, 1)$ the probability that a criminal is not punished for his crime (with a slight abuse of language, we will refer to this type of mistake as an acquittal error),¹³ $n \in (0, 1)$ the proportion of criminals (endogenously determined later), and $\alpha(x) \in [0, 1]$ the probability of an ID error for each acquittal error.¹⁴ Acquittal and ID errors depend on the standard of proof (x).

We present below the set of assumptions we will use to depict the impact of the standard of proof on the probabilities $\alpha(x)$, $\epsilon_a(x)$ and $\alpha(x) \epsilon_a(x)$. To begin with, we assume that a higher standard of proof increases the probability of an erroneous acquittal as more evidence is required to secure conviction.¹⁵

Assumption 1. $\epsilon_a(x) \in (0, 1)$, $\epsilon'_a(x=0) = 0$, $\epsilon'_a(x) > 0 \forall x \in (0, 1]$.

Furthermore, we assume the relation between erroneous acquittal and identity error is weaker the higher the standard of proof. Recall that erroneous acquittal can be associated either with the absence of any individual being found guilty (situation 1), or with the conviction

¹²Assuming there is only one individual guilty per crime.

¹³A criminal may avoid punishment either because he was caught by the police and prosecuted but acquitted by the court, or because he was not caught by the police or not prosecuted. Whatever the cause of the lack of punishment, we will refer to it as an acquittal error in the rest of the paper.

¹⁴Note 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”.

¹⁵The same hypothesis is made by [Mungan \(2011\)](#).

of the wrong person (situation 2). As more evidence is required when the standard of proof increases, situation 1 (situation 2) for each erroneous acquittal is more (less) likely. In other words, the probability of an ID error for each type 2 error decreases with the standard of proof.

Assumption 2. $\alpha(x) \in (0, 1]$, $\alpha'(x) < 0$.

Moreover, we assume that the overall effect of an increase of the standard of proof on the probability of an ID error for each crime committed is negative. In other words, for a given number of crimes, the expected number of wrongful convictions decreases with the standard of proof. We will discuss this assumption in section 3.2.

Assumption 3.

$$\frac{\partial(\alpha(x)\epsilon_a(x))}{\partial x} < 0 \forall x \in [0, 1] \Leftrightarrow \alpha'(x)\epsilon_a(x) + \alpha(x)\epsilon'_a(x) < 0 \forall x \in [0, 1]$$

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 only 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 $f(\cdot)$ and the cumulative distribution $F(\cdot)$ with support $[0, 1]$. This distribution is atomless and has a positive density over the whole support. There exists an exogenous non-monetary sanction $a \in (0, 1]$ (such as a term of imprisonment). The private marginal cost of the non-monetary sanction for a convicted criminal is normalized to 1. Recall that $n \in (0, 1)$ is the proportion of criminals (*i.e.* undeterred individuals). There exists a social marginal cost c of imposing the non-monetary sanction a .¹⁶ The social cost is financed by a tax t and the financing constraint will be specified later. Furthermore, we assume that individuals face a probability $\epsilon_c(x)$ of being detected, charged and convicted for the crime of another. We implicitly assume that this probability is the same for people deciding to commit or not (another) crime, as for

¹⁶We assume that there is no fixed costs for simplicity reasons.

instance in [Lando \(2006\)](#).¹⁷

Let $w \geq 0$ denote the wealth of individuals. The expected utility of law-abiding individuals is defined as:¹⁸

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

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

$$u_c = w + b - (1 - \epsilon_a(x)) a - \epsilon_c(x) a - nh - t \quad (3)$$

An individual decides to commit an offense if:

$$u_c \geq u_{nc} \quad (4)$$

That is if:

$$b \geq (1 - \epsilon_a(x)) a := \bar{b} \quad (5)$$

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

$$1 - F(\bar{b}) := n \quad (6)$$

¹⁷Alternatively, we could have assumed that this probability is slightly higher for offenders. In such a case, ID errors would have a higher marginal cost for offenders. Then, an increase in the standard of proof could have an ambiguous impact on deterrence. However, if deterrence decreases with the standard of proof (as it is the case when we assume that the probability $\epsilon_c(x)$ is the same whether the individual has committed a crime or not), our main results remain qualitatively unchanged. We believe that, even if the probability of a wrongful conviction (for another crime) is higher for offenders, it is likely that this condition is satisfied under a large set of specifications in our model. For this reason, but also for simplicity and for consistency with the previous literature regarding ID errors ([Lando, 2006](#), [Garoupa and Rizzolli, 2012](#)), we assume that the probability $\epsilon_c(x)$ is the same for all individuals.

¹⁸Henceforth, in a utilitarian perspective, we include the gains from crime.

2.3 Comparison with the socially optimal behavior

Let m be the probability that any individual (being the criminal or someone else) is convicted for a given crime as a function of the standard of proof (x):

$$m(x) = (1 - \epsilon_a(x)) + \alpha(x) \epsilon_a(x) \quad (7)$$

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

$$t = nm(x)ac \quad (8)$$

The social cost of punishing an individual is ac .¹⁹ The tax t has to cover these imprisonment term expenses for those convicted among the non-compliant (the proportion of which is $n(1 - \epsilon_a(x))$), plus the expenses for those who are convicted due to a mistake of identity (the proportion of which is $\epsilon_c(x) = \alpha(x)n\epsilon_a(x)$).

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

$$SW = F(\bar{b})u_{nc} + \int_{\bar{b}}^1 f(b)u_c db \quad (9)$$

By substituting u_{nc} and u_c in SW , and introducing the constraints on $\epsilon_c(x)$ and t given respectively by (1) and (8), we get:²⁰

$$SW = w + \int_{\bar{b}}^1 f(b)[b - m(x)a(1+c) - h] db \quad (10)$$

¹⁹By comparison, the private cost incurred by the individual found guilty is a .

²⁰By substituting u_{nc} and u_c in (9) according to (2) and (3) and rearranging, we find:

$$SW = w - nh - t - F(\bar{b})\epsilon_c(x)a + \int_{\bar{b}}^1 f(b)[b - (1 - \epsilon_a(x))a - \epsilon_c(x)a] db$$

Then, we substitute $\epsilon_c(x)$ and t in this expression according to (1) and (8):

$$SW = w - nh - nm(x)ac - \alpha(x)n\epsilon_a(x)a + \int_{\bar{b}}^1 f(b)[b - (1 - \epsilon_a(x))a] db$$

Let us now characterize the socially optimal behavior b_o of individuals (assuming for now that the standard of proof is exogenously given), as a matter of comparison with the threshold \bar{b} defined by (5). By substituting b_o for \bar{b} in (10) and differentiating SW with respect to b_o , we obtain:

$$\frac{\partial SW}{\partial b_o} = 0 \Leftrightarrow b_o = m(x) a (1 + c) + h \quad (11)$$

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

$$b_o - \bar{b} = h + (1 - \epsilon_a(x)) ac + \alpha(x) \epsilon_a(x) a (1 + c) := \Delta b > 0 \quad (12)$$

In other words, too many crimes are committed at the equilibrium by comparison with the social optimum, since $b_o > \bar{b}$. This result holds for all (a, x) combinations. Even for severe punishment (large a), the difference $b_o - \bar{b}$ between the optimal and the actual benefit from a crime threshold is strictly positive: there is under-deterrence.²¹

Proposition 1. *At equilibrium, for all (a, x) combinations, too many crimes are committed by comparison with the social optimum.*

Proof. The proof is in the text. □

This result can be explained by three effects. The first two are classical ones, found in the literature²² and showing that an individual who commits a crime: (i) generates an external

By rearranging, we obtain:

$$SW = w + \int_{\bar{b}}^1 f(b) \left[b - a \left(\underbrace{(1 - \epsilon_a(x)) + \alpha(x) \epsilon_a(x)}_{m(x)} \right) - m(x) ac - h \right] db$$

Simplifying this expression gives us (10).

²¹Moreover, we observe that when the standard of proof increases, the difference between the socially optimal behavior b_o and \bar{b} decreases. This decrease is exacerbated by ID errors since:

$$\frac{\partial \Delta b}{\partial x} = \underbrace{-\epsilon'_a(x) ac}_{\leq 0} + \underbrace{\frac{\partial (\alpha(x) \epsilon_a(x))}{\partial x} a (1 + c)}_{< 0} < 0$$

The second term of this expression is the effect of ID errors on Δb .

²²See for instance Polinsky and Shavell (1992), Garoupa (2001), and Rizzolli and Saraceno (2013).

harm which diminishes the utility of the entire population, and (ii) disregards the effect of their decision on the increase of tax for the entire population when their crime results in their conviction. The third effect is due to mistakes of identity and exacerbates the underdeterrence issue: an individual who commits a crime imposes another negative externality by generating a risk of an ID error, which increases the social costs through both tax and the loss of utility of the person wrongfully convicted. 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 (10). The standard of proof affects social welfare through (i) the level of deterrence, which is given by \bar{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 \bar{b}). We have:

$$\frac{\partial \bar{b}}{\partial x} = -\epsilon'_a(x) a < 0 \quad \forall x \in (0, 1] \quad \text{and} \quad \left. \frac{\partial \bar{b}}{\partial x} \right|_{x=0} = 0 \quad (13)$$

When the standard of proof increases, the probability of an acquittal error increases ($\epsilon'_a(x) \geq 0$). 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:

$$\frac{\partial m}{\partial x} = -\epsilon'_a(x) + [\alpha'(x) \epsilon_a(x) + \alpha(x) \epsilon'_a(x)] < 0 \quad (14)$$

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 the social welfare function SW with respect to the value of the standard of proof (x) is:²³

$$\frac{\partial SW}{\partial x} = \underbrace{\left[-\frac{\partial m}{\partial x} (1 - F(\bar{b})) a (1 + c) \right]}_{A > 0} - \underbrace{\left[-\frac{\partial \bar{b}}{\partial x} f(\bar{b}) \Delta b \right]}_{B \geq 0} \quad (15)$$

The first term (A) 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.

²³Differentiating SW with respect to x gives us:

$$\frac{\partial SW}{\partial x} = -\frac{\partial m}{\partial x} (1 - F(\bar{b})) a (1 + c) - \frac{\partial \bar{b}}{\partial x} f(\bar{b}) (\bar{b} - m(x) a (1 + c) - h)$$

This expression simplifies to (15).

Indeed, the probability of wrongful acquittal per crime increases and the probability of an ID error per crime committed decreases ([assumption 1](#) and [assumption 3](#)). The second term (B) 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](#)).

If $x = 0$, $A > 0$ and $B = 0$: the marginal cost of an increase in the standard of proof is zero, while the marginal gain is strictly positive. Thus, the standard of proof maximizing the social welfare function is always strictly positive. If $x = 1$, the marginal gain of an increase in the standard of proof may be higher than the marginal cost. In this case, we have a corner solution: $x^* = 1$. More specifically, this solution arises if:

$$A - B \geq 0 \text{ for } x = 1 \Leftrightarrow \frac{\partial m / \partial x}{\partial \bar{b} / \partial x} \geq \frac{f(\bar{b}) \Delta b}{(1 - F(\bar{b})) a (1 + c)} \text{ for } x = 1 \quad (16)$$

The corner solution $x^* = 1$ is consistent with the behavior of many jurisdictions and thus should not be excluded by assumption.²⁴

By rearranging [\(15\)](#), we obtain the following FOC when there is an interior solution to the optimal choice of the standard of proof:

$$-\frac{\partial m}{\partial x} (1 - F(\bar{b})) a (1 + c) = -\frac{\partial \bar{b}}{\partial x} f(\bar{b}) \Delta b \quad (17)$$

In the rest of our analysis, we focus on this interior solution. Since both A and B are continuous with respect to x on $[0, 1]$, and $A > B$ for $x = 0$, an interior solution $x^* \in (0, 1)$ always exists if condition [\(16\)](#) is not satisfied (*i.e.* if $A < B$ for $x = 1$). We believe this case to be the most relevant to our analysis.

²⁴As explained by [Guerra et al. \(2017\)](#), civil-law courts apply a higher standard of proof than common-law courts. Thus, a solution $x^* = 1$ may, for example, approximate the “intime conviction” principle used in France for example.

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 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 acknowledged). The scenario in which there are no ID errors is used as a benchmark. We assume in this benchmark scenario that the probability of an ID error for each acquittal error is $\alpha_1(x) = 0, \forall x \in [0, 1]$ (with subscript 1 for the absence of ID error scenario, or scenario 1 thereafter). Note that this benchmark is a different model from the one described in [section 2](#) since it violates [assumption 2](#) and [assumption 3](#).²⁵ For a more general proof comparing two scenarios in which the probabilities of ID errors are strictly positive, see the [appendix](#).

First, we compare the marginal gain from an increase in the standard of proof, 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 acknowledges the possibility of ID errors when he chooses the standard of proof (scenario 2, the probability of an ID error for each acquittal error is $\alpha_2(x) > 0$).²⁶ According to [assumption 3](#), the variation in the marginal social gain from an increase in the

²⁵We keep [assumption 1](#) in the benchmark (scenario 1).

²⁶We assume that there exists a unique interior solution for the optimal standard of proof in each of these scenarios.

standard of proof when we switch from scenario 1 to scenario 2 is positive²⁷:

$$- [\alpha'_2(x) \epsilon_a(x) + \alpha_2(x) \epsilon'_a(x)] na(1+c) > 0 \quad (18)$$

Therefore, the marginal gain of an increase in the standard of proof is higher when ID errors are likely, rather than in a scenario without ID error. Similarly, the variation in the marginal social cost resulting from an increase in the standard of proof is positive²⁸:

$$- \frac{\partial \bar{b}}{\partial x} f(\bar{b}) \alpha_2(x) \epsilon_a(x) a(1+c) \geq 0 \quad (19)$$

Therefore, the marginal cost of an increase in the standard of proof is higher when ID errors are likely, rather than in a scenario without ID error. Thus, there is an increase in the optimal standard of proof when we switch from scenario 1 to scenario 2 if the marginal gain given by (18) is strictly superior to the marginal cost given by (19).

²⁷The marginal gain from increasing the standard of proof when the probability of an ID error is strictly positive for each acquittal error (scenario 2, $\alpha_2(x) > 0$) is:

$$- \frac{\partial m}{\partial x} (1 - F(\bar{b})) a(1+c), \text{ with } \frac{\partial m}{\partial x} = -\epsilon'_a(x) + [\alpha'_2(x) \epsilon_a(x) + \alpha_2(x) \epsilon'_a(x)]$$

Without ID errors (scenario 1, $\alpha_1(x) = 0$), this marginal gain is:

$$- \frac{\partial m}{\partial x} (1 - F(\bar{b})) a(1+c), \text{ with } \frac{\partial m}{\partial x} = -\epsilon'_a(x)$$

The increase in the marginal gain when we switch from scenario 1 to scenario 2, is the difference between the two previous expressions. After simplification, this difference is:

$$- [\alpha'_2(x) \epsilon_a(x) + \alpha_2(x) \epsilon'_a(x)] na(1+c)$$

This expression is (strictly) positive since, according to [assumption 3](#), $\alpha'_2(x) \epsilon_a(x) + \alpha_2(x) \epsilon'_a(x) < 0$.

²⁸With ID errors, the marginal cost of increasing the standard of proof is:

$$- \frac{\partial \bar{b}}{\partial x} f(\bar{b}) \Delta b, \text{ with } \Delta b = h + (1 - \epsilon_a(x)) ac + \alpha_2(x) \epsilon_a(x) a(1+c)$$

Without ID errors, this marginal cost is:

$$- \frac{\partial \bar{b}}{\partial x} f(\bar{b}) \Delta b, \text{ with } \Delta b = h + (1 - \epsilon_a(x)) ac$$

The increase in the marginal cost when we switch from scenario 1 to scenario 2 is the difference between the two. This difference simplifies to (19).

Proposition 2. Define x_1^* as the optimal standard of proof in scenario 1 and assume $x_1^* < 1$. When introducing ID errors, the law enforcer (strictly) benefits from an increase in the standard of proof if:

$$- [\alpha_2'(x) \epsilon_a(x) + \alpha_2(x) \epsilon_a'(x)] n > - \frac{\partial \bar{b}}{\partial x} f(\bar{b}) \alpha_2(x) \epsilon_a(x) \text{ for } x = x_1^* \quad (20)$$

Proof. Condition (20) ensues directly from comparison of (18) and (19). □

The intuition behind [proposition 2](#) is the following. When acknowledging the likelihood of ID errors, the law enforcer faces additional marginal gain and cost. The left-hand side of equation (20) is the additional marginal gain. When the standard of proof increases, there is a larger decrease in the probability of a conviction for each crime in scenario 2 than in scenario 1 (*conviction effect*), thus allowing more savings in punishment costs. Indeed, increasing the standard reduces the probability of an ID error for each crime ([assumption 3](#)). The right-hand side of equation (20) is the additional marginal cost. When the standard of proof increases, deterrence decreases and more crimes are committed (*deterrence effect*). In scenario 2, this decrease in deterrence is costlier for society than in scenario 1 since committing a crime induces an additional externality by increasing the probability of an ID error (thus increasing punishment costs). Therefore, the law enforcer should adopt a higher standard of proof when being aware of ID errors if the additional net gain (via the *conviction effect*) is higher than the additional cost (via the *deterrence effect*). This trade-off does not depend on the value of the external harm (h).

[Proposition 2](#) implies that an increase in the standard of proof is more likely to be socially beneficial if: (i) the effect of the standard of proof on deterrence is sufficiently weak, (ii) the effect of an increase in the standard of proof on the probability of an ID error for each crime committed is weak (*i.e.* it is difficult to screen defendants by increasing the standard of proof), and (iii) the crime rate (n) is sufficiently high.²⁹ These conditions ensure that the

²⁹Conditions (i) and (iii) are more easily satisfied for low values of the non-monetary sanction a .

conviction effect is larger than the *deterrence effect*.

Less formally, when can we expect the *conviction effect* to be larger than the *deterrence effect*? We may conjecture the following. Firstly, the weak impact of the standard of proof on deterrence may be observed in crimes of passion (resulting in violent crimes like domestic assault, manslaughter or rape). Secondly, an increase in the standard of proof induces a large decrease in the probability of a conviction (high *conviction effect*) if a high standard of proof does not allow the court to screen efficiently between the guilty and the innocent (of this crime). For instance, we may conjecture that the screening effect of a high standard of proof may be more efficient when large investigations are conducted (*e.g.* murder, robbery). Thirdly, the *conviction effect* is reinforced for crimes that are rather common (a large proportion of the population chooses to commit the offense, such as petty larceny or narcotics use).³⁰

When we switch from scenario 1 to scenario 2, an increase in the standard of proof may be optimal only if [assumption 3](#) is satisfied. In other words, 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, the decrease in the probability of a mistake of identity (for each acquittal error) should be larger than 1%. We believe that this assumption is not a very strong one and is likely to be satisfied. Even if [assumption 3](#) is satisfied, condition (20) cannot be expected to hold for every criminal case. Thus, considering ID errors is not in itself sufficient to explain high standards of proof in criminal cases.

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.

³⁰However, in such examples (petty larceny, drugs), the sanction is often considered as being monetary.

Our main results are twofold. First, we show that the existence of mistakes of identity tends to exacerbate the gap between the equilibrium behavior and the optimal behavior, regardless of the value of the standard of proof. Indeed, crimes increase the probability of ID errors (and thereby private and public punishment costs), in addition to generating external harm and increasing expected imprisonment costs (following the conviction of the guilty). Second, we show that when the probability of an ID error per erroneous acquittal increases, 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 conviction for each crime committed, thus reducing the expected cost of punishment (*conviction effect*). On the other hand, increasing the standard reduces deterrence, thus increasing the expected cost of punishment (*deterrence effect*). As a consequence, our results suggest that the higher likelihood of ID errors in criminal cases such as robberies, assaults and homicides (where ID errors are likely), may justify the use of a higher standard of proof when punishment is costly, if the *conviction effect* dominates the *deterrence effect*.

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 mistakes on act. However, we believe that this 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).³¹ A third possible extension would be to consider ID errors in a dynamic setting.³² Such a setting should take

³¹As pointed out by an anonymous referee, even if we consider a purely monetary sanction, our main results remain true if the cost of administering the punishment is strictly positive (*e.g.* the social cost of public funds implies that society benefits less from the sanction than what it costs to the convicted person). In this case, ID errors still exacerbate the under-deterrence issue, and the trade-off between the *conviction effect* and the *deterrence effect* is likely to remain.

³²We would like to thank an anonymous referee for pointing this out.

into account the role of incapacitation ([Epps, 2015](#)). Incapacitation would allow to avoid other crimes being committed, and could prevent other ID errors.

5 Appendix

In this appendix, we generalize the result of [proposition 2](#). More specifically, we compare two scenarios in which ID errors may occur. The probabilities of an ID error for each acquittal error (and the effect of an increase in the standard of proof on this probability) in each scenario are distinct. The probability of an ID error for each acquittal error is $\alpha_1(x)$ in scenario 1 (respectively $\alpha_2(x)$ in scenario 2). Both $\alpha_1(x)$ and $\alpha_2(x)$ satisfy [assumption 1](#), [2](#) and [3](#), and we make the following additional assumptions:

Assumption 4. $\alpha_2(x) > \alpha_1(x) \forall x \in [0, 1]$.

Assumption 5. $\alpha'_2(x) < \alpha'_1(x) \forall x \in [0, 1]$.

According to [assumption 4](#), for a given level of the standard of proof, the probability of an ID error for each acquittal error is higher in scenario 2 than in scenario 1. [Assumption 5](#) ensures that an increase in the standard of proof results in a larger decrease of the probability of an ID error for each acquittal error in scenario 2 than in scenario 1. When we switch from scenario 1 to scenario 2, the variation in the marginal social gain from an increase in the standard of proof is:

$$\left[\underbrace{(\alpha'_1(x) - \alpha'_2(x)) \epsilon_a(x)}_{>0} + \underbrace{(\alpha_1(x) - \alpha_2(x)) \epsilon'_a(x)}_{\leq 0} \right] \times \underbrace{(1 - F(\bar{b})) a(1 + c)}_{>0} \quad (21)$$

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

$$\frac{\partial \bar{b}}{\partial x} f(\bar{b}) (\alpha_1(x) - \alpha_2(x)) \epsilon_a(x) a(1 + c) \geq 0 \quad (22)$$

Assume that the optimal standard of proof in scenario 1 is $x_1^* \in (0, 1)$ (we focus on an interior solution). When we switch from scenario 1 to scenario 2, the law enforcer (strictly) benefits

from an increase in the standard of proof if:

$$\begin{aligned} & [(\alpha'_1(x) - \alpha'_2(x)) \epsilon_a(x) + (\alpha_1(x) - \alpha_2(x)) \epsilon'_a(x)] n \\ & > \frac{\partial \bar{b}}{\partial x} f(\bar{b}) (\alpha_1(x) - \alpha_2(x)) \epsilon_a(x) \text{ for } x = x_1^* \quad (23) \end{aligned}$$

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

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