Guilty Beyond a Vague and Uncertain Doubt: Burdens of Proof Across Communities

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Abstract

The Fourteenth Amendment to the U.S. Constitution requires proof of guilt in criminal cases "beyond a reasonable doubt." This reasonable-doubt requirement is ill defined and poorly understood, leaving communities to determine their own definitions of reasonable doubt. We examine the effects of such a vague burden of proof and find three major results. First, wealthier communities are less concerned with wrongful convictions and thus select a lower threshold for conviction to better deter crime. Second, communities with greater income inequality select a higher threshold because the median voter is more likely to be a potential criminal. Finally, in civil cases, the threshold depends neither on income nor income inequality. This final result justifies why, unlike in criminal law, courts have quantified the civil burden of proof (preponderance of the evidence) as greater than a 50% probability of wrongdoing. To estimate actual reasonable doubt thresholds, we survey public defenders in the Commonwealth of Kentucky. Our results show that even among those with a strong professional incentive to understand the threshold, estimates of juries' actual thresholds vary wildly.

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1 Introduction

The reasonable doubt standard of proof is a "vital" and "indispensable" component of American criminal jurisprudence.[1] It is the fulcrum point for guilt or innocence; when the prosecution's proof leaves a reasonable doubt in the minds of the jurors about the defendant's guilt, the jurors must acquit the defendant of the alleged crimes.[2] The U.S. Supreme Court has famously held that the reasonable doubt standard of proof is the "prime instrument for reducing the risk of wrongful convictions," and that it provides "concrete substance for the presumption of innocence," which is a "bedrock axiomatic and elementary principle whose enforcement lies at the foundation of the administration of criminal law."[3]

Given its lofty status, one would expect courts to zealously ensure that jurors understand and uniformly apply the reasonable doubt standard. In fact, the opposite is true. The U.S. Supreme Court, and the majority of lower courts, are content to leave the reasonable doubt standard ill-defined and almost never quantified. It is therefore not surprising that overwhelming empirical evidence, including our own, demonstrates that jurors (and lawyers and judges) have widely divergent views about what reasonable doubt means and how it should operate in a particular case.

The absence of guidance on the meaning of reasonable doubt is consistent with another prominent feature of American criminal law: the Sixth Amendment right to be tried in the community where the crime was committed. Differences in economic variables, such as income and income inequality can affect how a community perceives the risks of becoming a victim either of a crime or of a wrongful conviction. It is therefore plausible that different communities will select different quantitative thresholds of reasonable doubt. This paper models how different communities determine these thresholds.

By not imposing a clear and uniform reasonable doubt standard, and by encouraging verdicts that reflect the conscience of the community, the American legal system allows for controversial outcomes. Consider two defendants accused of the same offense. In one community a jury may convict based on its belief that the accused is guilty with probability 0.9, determining that a 10% likelihood of innocence is not reasonable doubt. Another jurisdiction may, however, acquit the other defendant having concluded that she is guilty with probability 0.95, determining that a 5% chance of innocence is reasonable doubt. We take take no position regarding whether this scenario is an acceptable result of community standards or a grave miscarriage of justice.[4] Our focus is to examine how economic

[1] *In re Winship*, 397 U.S. at 363-64 (1970).

[2] *Id.* at 364.

[3] *Id.* at 363 (internal citation omitted).

[4] Legal arguments on both sides of this debate abound. For example, see Nesson (1979) for an argument in favor of an undefined reasonable doubt standard, and Solan (1999) and Fortunato (1996) for arguments in favor of a more precise

disparities may cause such an outcome. We find that this outcome may occur if the former community is wealthier or exhibits less income inequality than the latter community.

To examine burdens of proof, we develop a three stage model of the legal system. In a given case, jurors lack a strong non-altruistic motive to correctly judge a defendant's guilt or innocence. Rather than include altruism in jurors utility functions, however, we assume that the community's values are correlated with the reasonable doubt thresholds employed by juries. This is a standard assumption in the legal literature. Chambers (1998) explains it thusly: "The decision to imprison a citizen is a societal decision. Society has the right and duty to define guilt and the conditions under which defendants will be incarcerated, subject to constitutional limitations. Society seeks to punish the guilty and free the innocent through a justice system that functions to insure that society's goals are met. If particular procedures become impediments to successfully identifying and punishing the guilty, those procedures may be reinterpreted and restructured in order to allow the system to function properly." At bottom, "the question that is ultimately asked in a criminal trial is not merely whether the defendant is guilty, but rather, whether the defendant is certainly guilty. The criminal justice system uses skepticism, in the form of the reasonable doubt standard and the presumption of innocence, to determine whether a defendant is certainly guilty." Necessarily then, "[t]he appropriate level of skepticism to be applied in the criminal justice system depends on the results society wants from the system."[5] Justice Harlan made the same point decades earlier in his concurring opinion in *In re Winship*, where he argued that thresholds of proof represent "the degree of confidence our society [has] in the correctness of factual conclusions," and should "reflect an assessment of the comparative social disutility" of erroneous outcomes.[6]

Our model works as follows: In Stage 1, each agent chooses their own threshold of proof, the level of confidence in guilt needed to convict, knowing that they themselves must live under whichever value the society selects. Each agent must balance their incentive to deter crime through lower thresholds with their desire to minimize the chances of being personally convicted and punished. In Stage 2, a mechanism (median voter) maps from individual preferences to the societal threshold. Finally, in Stage 3, each agent chooses whether or not to commit crime; simple theft in our model. If a trial results, we assume that the petit jury simply implements the community's pre-determined threshold.[7]

We focus on two puzzles from American jurisprudence. First, what is the effect of allowing local communities to determine their own thresholds? Our model of property theft predicts that wealth

definition of reasonable doubt.

[5]For a similar argument, see Thomas III and Pollack (1992).

[6]*Winship*, 397 U.S. at 370-371 (Harlan, J. concurring).

[7]In the American legal system, the petit jury typically consists of 6 or 12 people empaneled for the trial of a specific case.

has two effects on the definition of reasonable doubt. One, wealthier communities suffer a smaller utility loss if one unit of income is stolen from them, and they are therefore inclined to choose a higher threshold of proof.[8] Two, because crime rates are lower in wealthier communities, wrongful accusations are less likely and these communities can select a lower threshold of proof because the fear of wrongful convictions is reduced. We show that the latter effect dominates in our model and wealthier communities thus select a lower threshold of proof in criminal trials. We also find that greater income inequality results in a higher threshold of proof. In a society with heterogeneous income, the minority of potential criminals is unable to affect the median choice of a reasonable doubt threshold. With income heterogeneity, however, the median voter may be a potential criminal who then selects a higher threshold in order to reduce her personal risk of being justly convicted.

The second puzzle we explore is why is the civil burden of proof - preponderance of the evidence - is both lower than reasonable doubt and definitively quantified (as greater than 50%). We find that the civil burden of proof does not depend on either income or income inequality. In a criminal trial, the guilty person's punishment may include incarceration, which provides a disutilty to that person but no tangible utility to the victim.[9] In civil cases, however, the guilty person's loss is the victim's gain. A citizen is thus as likely to benefit from a mistaken verdict (as a crime victim receiving restitution from the wrong person) as they are to be harmed (by having to provide restitution for a crime that they did not commit). It thus follows that communities, regardless, of income, choose the threshold of proof that minimizes crime.[10] Because this threshold does not depend on the demographics of the community, there is no need for the legal system to avoid quantifying its precise value.

Our paper is organized as follows. Section 2 summarizes the legal landscape, including the confusing and often contradictory efforts of courts to explain reasonable doubt. Section 3 describes the related economics literature. Section 4 develops the model, and Section 5 presents our formal Propositions. Section 6 provides survey data from public defenders in the Commonwealth of Kentucky, which demonstrate that even trial lawyers, with a strong motivation to understand reasonable doubt, strongly disagree over its quantitative value. The data also provide some evidence in support of our result that higher income results in a lower reasonable doubt standard. Section 7 concludes.

[8]This effect may be weakened or reversed, however, if thieves steal larger amounts from the wealthy than the poor. This alternate assumption would strengthen our result that wealthier communities are more willing to convict accused criminals than poorer communities.

[9]Criminal punishments may include restitution for the victim. Adding this feature to our criminal trial model does not affect the Propositions of Section 5.

[10]We do not model the deadweight loss of litigation. Doing so would add an additional motivation for minimizing crime and thus reducing legal costs. A higher threshold could also, however, disincentivize meritless lawsuits, although we do not include this effect in our model.

2 Legal Landscape

We examine the intersection of two constitutional rights: the right of the accused to protection from "conviction except upon proof beyond a reasonable doubt of every fact necessary to constitute the crime charged"[11] and the right to trial "by an impartial jury of the State and district wherein the crimes shall have been committed."[12] These two rights interject abstruseness into the system, which enables communities to select their own reasonable doubt thresholds.

We start with the reasonable doubt standard of proof. In every criminal trial, jurors are instructed that they must acquit unless the prosecution has proved the defendant's guilt beyond a reasonable doubt. Reasonable doubt is almost never quantified[13]; and there is no legal consensus on what that number would be.[14] Instead of quantifying the term, reasonable doubt is either defined qualitatively or it is not defined at all.

This ambiguity persists because the U.S. Supreme Court has never quantified reasonable doubt. The Court has, however, repeatedly instructed that "[a] 'reasonable doubt,' at a minimum, is one based upon reason."[15] This is intended to be instructive, and not sarcastic. The best one can say is that the Court's jurisprudence has been confusing. For example, the Court has whipsawed between defining reasonable doubt as the degree of certainty "you would be willing to act upon in the more weighty and important matters relating to your own affairs,"[16] only to later hold that reasonable doubt should be worded "in terms of the kind of doubt that would make a person hesitate to act, rather than the kind

[11] *In re Winship*, 397 U.S. 358, 364 (1970).

[12] U.S. Constitution, Amendment VI.

[13] Kramer and Koenig (1990) collect jury instructions that have attempted to quantify reasonable doubt; all were subsequently struck down. In other cases, football analogies have been used to quantify reasonable doubt. In *Brooks v. State*, 323 S.W.3d 893, 923 (Tex. Crim. App. 2010), the appellate court analogized the reasonable doubt standard to a football field, where one end zone represented "no evidence" and other "conclusive evidence;" the court explained, "reaching midfield is never enough to meet the beyond a reasonable doubt standard." In *State v. Casey*, 2004 WL 405738, *6-7 (Ohio App. 2 Dist. 2004), the prosecutor told the jurors during closing arguments: "I like to make it kind of like a football field where you start at one end and you go to the other. If you go all the way and make a touchdown, that's like a hundred percent. That's beyond no doubt. I like to say reasonable doubt is kind of like 75 percent. Somewhere - 75 and 90. Now, you're not going to hold me to going all the way for a touchdown, are you?" The appellate court refused to overturn the defendant's conviction because of that analogy.

[14] McCauliff (1982) surveys 171 federal judges to quantify the conviction threshold for reasonable doubt. The judges gave varying responses: 126 judges said 90% or more (56 judges said 90%, 3 judges said between 92-94%, 31 judges said 95%, 1 judge said 97%, 6 judges said 98%, 8 judges said 99%, and 21 judges said 100%); 8 judges said 75% and 3 judges accepted even lower thresholds (1 judge said 50%).

[15] *Victor v. Nebraska*, 511 U.S. 1, 17 (1994); *Jackson v. Virginia*, 443 U.S. 307, 317 (1979); *Johnson v. Louisiana*, 406 U.S. 356, 360 (1972).

[16] *Hopt v. People*, 120 U.S. 430, 440 (1887).

on which [a person] would be willing to act."[17] The Court has also considered a variety of different instructions that define reasonable doubt using a combination of different phrases. The Court has unanimously held that "grave uncertainty," plus "actual substantial doubt," and "moral certainty," is unconstitutional.[18] It has also unanimously held that "moral evidence," plus "not a mere possibility of doubt," and "moral certainty," passes constitutional muster.[19] The Court divided on the question of whether "strong possibilities," plus "substantial doubt," and "moral certainty," offend the constitution; ultimately, the majority concluded that it does not.[20] Obviously, these fine-tuned distinctions are lost on the average juror. By the Court's own admission, its "attempts to explain the term reasonable doubt do not usually result in making it any clearer to the minds of the jury."[21] And, for all the Court's trouble, it appears that the lower courts are not listening. For example, ten of twelve Circuit Courts of Appeal have reviewed and upheld instructions using the phrase "moral certainty" despite the U.S. Supreme Court's reluctance to condone the definition.[22]

Because the U.S. Supreme Court has failed to provide clear guidance on the proper legal meaning of reasonable doubt, and because an improper jury instruction may be grounds for reversal of a criminal conviction,[23] many lower courts prohibit defining the term at all.[24] In these cases, jurors are informed that the government must prove its case "beyond a reasonable doubt," and nothing more.[25]

Empirical evidence confirms that jurors are ill-informed about what reasonable doubt means or how to apply the concept, regardless of whether they have received a qualitative instruction. The legal system does clearly interpret reasonable doubt as a higher burden than preponderance of the evidence, which is understood as greater than 50%. Strawn and Buchanan (1976), however, find that 23% of instructed jurors, *i.e.* jurors that had received some instruction on the meaning of reasonable doubt, believed that when the weight of circumstantial evidence was equally balanced between guilt and innocence, the defendant should be convicted. Saxton (1998), finds similar results; 27% of instructed jurors either did not know or incorrectly believed that a greater than a 50% chance of guilt was suffi-

[17] *Holland v. United States*, 348 U.S. 121, 138 (1955).

[18] *Cage v. Louisiana*, 498 U.S. 39, 41 (1990) (per curiam).

[19] *Victor*, 511 U.S. at 10-17 (the Sandoval instruction).

[20] *Id.* at 18-23 (the Victor instruction).

[21] *Miles v. United States*, 103 U.S. 304, 312 (1880).

[22] See Corwin (2001).

[23] See *Sullivan v. Louisiana*, 508 U.S. 275, 281-82 (1993).

[24] *Victor*, 511 U.S. at 5 ("the Constitution neither prohibits trial courts from defining reasonable doubt nor requires them to do so as a matter of course.")

[25] *Id.* at 5, "[S]o long as the court instructs the jury on the necessity that the defendant's guilt be proved beyond a reasonable doubt, the Constitution does not require that any particular form of words be used in advising the jury of the government's burden of proof."(internal citation omitted). For a discussion of the varying approaches to defining, or not defining, reasonable doubt, see Diamond (1990).

cient to convict, and an additional 15% were only "pretty sure" that a greater degree of confidence was required. Kramer and Koenig (1990) find that only 25% of instructed jurors correctly understood that reasonable doubt does not mean "any possibility, no matter how slight," and only 31% of instructed jurors correctly understood that 100% certainty was not required in order to convict.[26]

Jury verdicts in criminal cases reflect a community's idiosyncratic view of the quantum of proof necessary for a conviction, rather than some uniformly-applied benchmark.[27] This is consistent with the Sixth Amendment's guarantee of a trial "by impartial jury of the State and district wherein the crime shall have been committed," which we turn to next.

The "insistence upon community participation in the determination of guilt or innocence" is a fundamental component of criminal trials.[28] A community-based jury gives the defendant an "inestimable safeguard against the corrupt or overzealous prosecutor and against the compliant, biased or eccentric judge."[29] Jury verdicts are intended to reflect "the commonsense judgment of a group of laymen" and "the shared [community] responsibility that results from that group's determination of guilt or innocence."[30]

One of the reasons why the jury must be "truly representative of the community,"[31] is because juries are expected to "express the conscience of the community."[32] The law recognizes that juries "inevitably make decisions based on community values."[33] For example, in *Witherspoon v. Illinois*, the U.S. Supreme Court recognized that "a jury that must choose between life imprisonment and capital punishment can do little more - and must do nothing less - than express the conscience of the community on the ultimate question of death."[34] The Court added that "one of the most important functions any jury can perform...is to maintain a link between contemporary community values and the penal system - a link without which the determination of punishment would hardly reflect the evolving standards of decency that mark the progress of a maturing society."[35] In sum, a jury verdict

[26] Additional empirical research in this area, which is largely consistent with the above-referenced studies, is summarized in Solan (1999).

[27] In some cases, jurors are told that the reasonable-doubt standard is more exacting than the preponderance of the evidence standard, which is routinely quantified as more than 50%.

[28] *Duncan v. Louisiana*, 391 U.S. 145, 156 (1968).

[29] *Id.* at 156.

[30] *Williams v. Florida*, 399 U.S. 78, 100 (1970); see also 4 W. Blackstone, Commentaries on the Laws of England 343 (1769) (Blackstone described "trial by jury" as requiring that "the truth of every accusation should afterwards be confirmed by the unanimous suffrage of twelve of [the defendant's] equals and neighbors.")

[31] *Taylor v. Louisiana*, 419 U.S. 522, 527 (1975); *Glasser v. United States*, 315 U.S. 60, 85-86 (1942); *Smith v. Texas*, 311 U.S. 128, 130 (1940).

[32] *Witherspoon v. Illinois*, 391 U.S. 510, 519 (1968).

[33] *Spaziano v. Florida*, 468 U.S. 447, 486-87 (1968) (Stevens, J., concurring in part and dissenting in part).

[34] *Witherspoon*, 391 U.S. at 519.

[35] *Id.* at 520 n. 15 (internal citation omitted); *Spaziano v. Florida*, 468 U.S. 447, 462 (1984).

in a criminal case is intended to embody "community values" and society's definition of "reasonable doubt."

3 Related Literature

A small literature in economics examines the causes and effects of burden of proof thresholds in a legal system. This literature typically assumes that juries are not directly affected by their verdicts but instead are motivated by altruism; they obtain utility from ruling correctly and disutility from either wrongful convictions of the innocent or wrongful acquittals of the guilty. Andreoni (1991), for example, develops a model where jurors require a higher threshold of proof for harsher punishments. It thus follows that unduly harsh punishments may result in less deterrence and more crime.[36] Lando (2009) examines reasonable doubt standards in a model that he then applies to violent crimes against women. As in our model, agents make a Becker (1968) type choice of whether to commit a crime for a given reasonable doubt threshold. That paper focuses on solving for the optimal reasonable doubt standard for a given social welfare function as opposed to solving for a reasonable doubt standard as an endogenous result of agents' preferences. Mungan (2011), like us, assumes that reasonable doubt thresholds are a function of the entire criminal justice system and not just individual jurors acting altruistically. That paper shows that, if non-criminals devote resources to reducing their risk of wrongful convictions, then wrongful convictions may be worse than wrongful acquittals and it is thus optimal to have a high threshold of proof. Our focus, however, is on the relationship among economic conditions and reasonable doubt standards, explaining the American legal system's reluctance to clearly articulate (or quantify) and standardize reasonable doubt thresholds, and understanding why different communities may have different thresholds.

Other papers examine thresholds of proof in less related ways. Curry and Klumpp (2009) model how a jury decides whether evidence reaches the level of a given reasonable doubt threshold. They find that differences in income among racial groups may affect a jury's prior beliefs, which causes the amount of evidence needed to convict to vary across the race of the accused. This result may then reinforce the existing prior beliefs about different groups' guilt. Other papers examine how the threshold of proof affects the level of effort supplied by either prosecutors or defendants.[37] Kaplow (2011) examines the effect of reducing the threshold of proof and the resulting deterrence of benign behavior. Demougin and Fluet (2006 and 2008) examine the optimality of the preponderance of the evidence standard.

[36] Feess and Wohlschlegal (2009) obtain a similar result and show that excessive punishments may also reduce the informativeness of evidence.

[37] See, for example, Rubinfeld and Sappington (1987), Miceli (1990), and Yilankaya (2002).

Our paper is also related to a literature that examines the relationship among aggregate crime rates and economic conditions. Benoit and Osborne (1995) examine the optimal levels of enforcement and redistributive transfers in a model where these policies can both deter crime and result in wrongful convictions. The probability of wrongful convictions does not depend on an endogenous reasonable doubt threshold. Chiu and and Madden (1998) find that income inequality increases burglary rates. Di Tella and Dubra (2008) find that belief in the "American Dream" results in harsher punishments.

Finally, our paper is related to the long literature that examines the relationship between crime and the expected punishment. In the seminal paper of Becker (1968), as well as many related papers, harsher punishments provide a greater deterrent effect.[38] Often, the optimal policy is an extreme punishment, possibly implemented with low probability. Our model can produce this type of result as well. It requires that all potential criminals be open to deterrence and that society view just and wrongful convictions equally. We show, however, that this result requires that society allow convictions when the probability of wrongful convictions is greater than $\frac{1}{2}$. Such a result is not plausible for the American legal system, or most others. We show that reasonable doubt thresholds consistent with the American legal system require both that wrongful convictions result in more disutility than just convictions, and that punishments be sufficiently mild.

4 Model

We develop a three stage model that determines a society's reasonable doubt threshold. In the first stage, each agent chooses their preferred reasonable doubt threshold. In stage two, a mechanism maps from individuals' reasonable doubt thresholds to a society-wide threshold. Finally, in stage three, each agent decides whether or not to commit crime.

We assume that there are two types of agents. A fraction of agents, $\gamma \in [0, \frac{1}{2})$ are serial criminals who always commit a crime, and the remaining $(1-\gamma)$ fraction of agents rationally choose whether or not to commit a crime. We assume the following utility function:[39]

$$U(y,p) = r(y + p^* - c(y)) - jp^* - p^*\Omega f(d) - \tau\Omega q(d)c(y) \tag{1}$$

where $r(y + p^* - c(y))$ is a function equating net income to utility and p^* equals one, representing income aquired from theft, if the agent chooses to commit a crime, and it equals zero if she does not.

[38] Other prominent examples include Erlich (1973) and Furlong (1987).

[39] Serial criminals may include the mentally ill, members of the New England Patriots, agents who commit a crime by mistake, or agents with exotic preferences who obtain significant utility from the act of committing the crime.

We later assume, in A(2), that crime is distributed evenly across income types.[40] $c(y)$ is the fraction of criminals to the population, and this crime rate thus equals income lost to crime. Because there is no uncertainty, $y + p^* - c(y)$ equals net income. There are two types of potential heterogeneity among agents. First, each agent obtains exogenous income equal to y. Second, each agent obtains disutility equal to j if and only if she chooses to commit the crime. We are thus assuming that agents intrinsically dislike committing crime.

If an agent is convicted of a crime, she is punished and obtains the exogenous disutility Ω. The function $f(d)$ represents the probability that, if she commits a crime, she is justly convicted. The function $q(d)$ is the probability that a crime results in a wrongful conviction. We assume that wrongful convictions yield disutility $\tau\Omega$ where $\tau \geq 1$. We assume that j is unobservable and the likelihoods of being convicted (justly or wrongfully) thus do not depend on its value. The term $c(y)$ is the crime rate for agents with income y.

Agents obtain utility from their net income. Our model of crime is based on property theft. By stealing, agents increase their income by one unit.[41] If $r(\cdot)$ is concave, then this assumption provides a strong incentive for wealthy agents to choose a higher reasonable doubt threshold than poorer agents. Despite this assumption, however, Section 5 demonstrates that wealthier societies choose a lower threshold (and are thus more willing to convict) because they are less concerned with wrongful convictions. An alternate assumption, such as that crime victims lose an exogenous fraction of their wealth, would therefore strengthen our result.

We begin be examining communities with homogenous income levels, focusing on how this level of income affects crime and the reasonable doubt threshold. We thus make the following assumptions:

(A1): If a wrongful conviction occurs, then a random agent with the same y as the true culprit is punished.

(A2): Criminals only steal from other agents with the same y and theft is evenly distributed within each income type.

These assumptions result in the losses from theft equaling $c(y)$ and the probability of being wrongfully convicted being proportional to $c(y)$. Sections 5.2 and 5.3 extend our model to communities with heterogeneous levels of income. The latter section relaxes (A1) (A2) by assuming that wrongful accusations are independent of income, and that the costs of crime are evenly distributed across income types. Surprisingly, our results are unaffected.

[40] We also considered a version where whether one is a victim of crime is random. This adds a non-linearity that does not affect our main results.

[41] We assume that agents are able to enjoy the fruits of their crime even if they are convicted.

We now impose additional structure on $f(d)$ and $q(d)$. We denote d as society's reasonable doubt threshold; *i.e.* the level of confidence in the accused's guilt needed for a conviction. We assume that, for every crime, the criminal justice system exogenously identifies a suspect and establishes that she is guilty with probability g. The following outcomes then occur:

$$\begin{cases} \text{if } g < d & \text{then there is no conviction} \\ \text{if } g \geq d & \text{then a conviction occurs, correctly } \textit{w.p. } g \end{cases} \tag{2}$$

If an agent is not convicted, we assume that she obtains no disutility.[42] We make the following distributional assumption:

(A3): We assume that g is uniformly distributed on the interval $[\alpha, 1]$ where $\alpha < \frac{1}{2}$. We assume that potential criminals are aware of the distribution of g, but not its realized value until after committing the crime.

Assumption (A3) is for convenience. Different distributions may be considered without adding much generality. The parameter α captures the efficiency of how suspects are identified; higher values of α imply that the identified suspect is more likely to be guilty. We soon show that increasing α increases both the rate of correct and incorrect convictions for a given value of d.

(A1) and (A3) yield functional forms for the probability of convictions. The probability of any conviction occurring is simply the range of possible values for g where $g > d$, to the entire range of possible values for g. This equals $\frac{1-d}{1-\alpha}$. The probability of no conviction occurring is likewise $\frac{d-\alpha}{1-\alpha}$. Given that a conviction occurs the probability that it is correct is the average value of g over $(d, 1)$, which equals $\frac{1+d}{2}$. The overall rate of correct convictions is thus:

$$f(d) = \frac{1-d}{1-\alpha} * \frac{1+d}{2} = \frac{(1-d^2)}{2(1-\alpha)} \tag{3}$$

The functional form of the wrongful conviction rate is thus:[43]

$$q(d) = 1 - f(d) - \frac{d-\alpha}{1-\alpha} = \frac{(1-d)^2}{2(1-\alpha)} \tag{4}$$

Finally, we assume that $y \in (1, \hat{y})$, and that j is uniformly distributed on the interval $[0, \hat{j}]$.

Stage 3, Choosing Crime

[42] It thus does not matter if the suspect is acquitted, if the charges are dropped, or if she is never identified as a suspect.

[43] For simplicity, we assume that an agent may be both justly convicted (of a crime she did commit) and wrongfully convicted (of a crime she did not commit).

The final stage of the game is a Becker (1968) type binary choice of whether to commit crime. Agents choose $p^*(y, j)$ taking d, and thus $f(d)$ and $g(y)$, and $c(y)$ as given. Agents face a simple tradeoff, crime increases net income, but increases the chances of punishment and provides intrinsic disutility. We make the following assumption about $r(y + p^* - c(y))$:

(A4): $r(y + p^* - c(y))$ is defined so that the marginal benefit of an additional unit of net income is $\frac{1}{y}$.

We choose this functional form for convenience, any utility function that is concave in income will yield similar results. It follows that that an agent of type (y, j) commits a crime if and only if the marginal benefit to their income outweighs the marginal increase in the risk of punishment plus the intrinsic disutility of stealing:

$$\begin{cases} \text{if } \frac{1}{y} \geq j + \Omega f(d) & \text{then } p^* = 1 \\ \text{if } \frac{1}{y} < j + \Omega f(d) & \text{then } p^* = 0 \end{cases} \tag{5}$$

For a group of agents with income y, we define $\tilde{j}$ as the threshold value of j below which an agent chooses to commit crime. In order to ensure an interior solution such that $d^* > \alpha$, and $c(y) > 0$ for all y, we impose the following condition:[44]

(A5): $\hat{y} < 2\Omega^{-1}$.

It follows from (5) that:

$$\tilde{j} = \frac{1}{y} - \Omega f(d) \tag{6}$$

The crime rate for agents with income y then equals:

$$c(y) = \gamma + \frac{1-\gamma}{\hat{j}} \left[\frac{1}{y} - \frac{\Omega(1-d^2)}{2(1-\alpha)} \right] \tag{7}$$

Equation (7) exhibits two intuitive properties. First, the crime rate is decreasing in income. Poorer agents possess a higher marginal utility of income than wealthier agents and thus benefit more from theft. Second, the crime rate is increasing in the reasonable doubt threshold. As d increases, a criminal is less likely to be convicted and the deterrent effect of punishment is diminished.

Including a measure of agents γ who always commit a crime obviously increases the crime rate. Their presence is not required to analyze the model, nor do they affect the model's main results. As shown in Section 5.1, however, they do help the model yield reasonable doubt thresholds in the neighborhood of those observed in the American justice system.

[44] Eliminating this condition may result in corner solutions. The model's main results, however, are unaffected.

Stage 2: Societal Choice of Reasonable Doubt

For any function $d(y, j)$, we assume that the societal-wide reasonable doubt threshold, d^*, is simply the median individual standard in a given population of agents. Our focus is on society's determination of reasonable doubt, not the dynamics of juries. We thus assume that each defendant's probability of guilt, g, is perfectly observable to all members of a potential jury, and that juries simply implement society's standard. It thus follows that the defendant is convicted, or agrees to a plea bargain, if and only if $g > d$.[45]

In general, we cannot rule out pathological cases where the median agent is a criminal and thus chooses a relatively high d^* in order to affect her own chances of punishment. As crime rates over 50% are not empirically plausible, we rule out such outcomes by assuming that:

$$\hat{j} > \frac{1-\gamma}{\frac{1}{2}-\gamma} \tag{8}$$

It follows directly from (7) that (8) ensures that for any distribution of income and any doubt threshold, the societal crime rate is less than one-half. The median agent thus always chooses d^* knowing that she will not commit a crime.

Our model assumes that while the national government does not impose a reasonable doubt standard, local communities do, and are able to implement it. We view the choices of judges and prosecutors, and public funding decisions as mechanisms that allow for such implementation. An alternate approach, however, is to instead assume that the reasonable doubt standard reflects the preferences of individual juries, most plausibly by assuming that the actual threshold matches that of the juror with the highest threshold.[46] For the analysis of homogeneous societies that follows, this approach makes no difference because all agents choose the same standard. For the analysis of heterogeneous societies, this alternate approach raises the threshold to match that of the poorest juror (assuming that guilty verdicts require unanimity). This would thus strengthen our findings that follow which show that heterogeneous societies will set higher reasonable doubt thresholds and that convictions will thus be harder to obtain.

Stage 1: Individual Choice of Reasonable Doubt

We now solve for individuals' choice of $d(y)$. Equation (8) ensures that the median agent in a

[45] 94% of state convictions and 97% of federal convictions result from plea bargains. (See *Missouri v. Frye*, 132 S.Ct. 1399, 1407 (2012)) Because both g and d are known at the trial stage in our model, a plea bargain will occur if the prosecutor and defendant are able to bargain over even a small surplus. This surplus may include the cost and effort involved with holding a trial.

[46] In most cases, guilty verdicts require unanimity.

homogeneous (in income) society always chooses d^* knowing that she will not commit a crime. We thus only consider this type of agent's choice of a reasonable doubt threshold. The agent chooses $d(y)$ knowing that higher values result in more crime and thus more property loss. She must also consider the effect of d on her probability of being wrongfully convicted. The latter effect is non-monotonic. Higher values of d reduce the probability of being convicted conditional on being falsely accused. Because higher values of d increase the crime rate, however, they increase the chances of being falsely accused.

Differentiating (1) with respect to d yields the associated first-order condition:

$$-r'c_d(y) - \tau\Omega c(y)q_d(y) - \tau\Omega c_d(y)q(d) = 0 \tag{9}$$

Consider each of the three terms in (9). The first term represents the marginal benefit of consumption resulting from a change in the reasonable doubt threshold and therefore crime rates. The second term captures the change in the probability of being falsely convicted in the event that the agent is wrongfully accused. The final term captures the change in the probability of being falsely accused that results from a change in the crime rate. For the functional forms from (4) and (7), this first-order condition becomes:

$$-\frac{\tau^{-1}d(1-\gamma)}{y} + (1-d)\left[+\gamma\hat{j} + \frac{1-\gamma}{y} - \frac{(1-\gamma)\Omega(1-d^2)}{2(1-\alpha)}\right] - \frac{d(1-d)^2\Omega}{2(1-\alpha)} = 0 \tag{10}$$

The resulting solution $d(y)$ is the optimal choice of reasonable doubt for an agent of income y. From (A5), $\frac{\partial U(y,p)}{\partial d}$ is positive when evaluated at $d = \alpha$, and it is direct to verify that it is negative when evaluated at $d = 1$. It is also direct to verify that $\frac{\partial^2 U(y,p)}{\partial d^2} < 0$ for all $d \in (\alpha, 1)$. A unique solution therefore exists on the interval $d \in (\alpha, 1)$.

5 Results

5.1 Homogeneous Society Results

In this section, we compare reasonable doubt thresholds for different societies, each of which has a homogeneous level of income. Without heterogeneity, the societal-wide reasonable doubt threshold is simply $d^*(y) = d(y)$. We begin by analyzing a special case of the model where all potential criminals are rational ($\gamma = 0$) and agents do not differentiate between being justly and wrongfully punished ($\tau = 1$). This special case maximizes the deterrent effect of lower values of d and minimizes agents' concerns over wrongful convictions. It thus results in the minimum value of $d^*(y)$.

Proposition 1. *For sufficiently small γ, $d^*(y) < \frac{1}{1+\tau^{-1}}$. Thus if $\tau = 1$ and $\gamma = 0$, then $d^*(y) < \frac{1}{2}$.*

Proof: See Proof Appendix.

Blackstone's famous formulation states that "better that ten guilty persons escape than that one innocent suffer."[47] We interpret this sentiment as $\tau > 1$ in our model. Proposition 1 considers a special case that rejects Blackstone's formulation. The resulting burden of proof is implausibly low when compared to the American, and most other, legal systems. Beyond a reasonable doubt is widely understood to be a higher burden than preponderance of the evidence, which the legal profession views as a greater than 50% standard.[48]

This result occurs because of two factors. First, agents are relatively unconcerned about wrongful convictions and are relatively willing to risk such an outcome in order to deter crime. Second, because $\gamma = 0$, the deterrent effect of lowering d is very strong in this case. Although agents do wish to prevent wrongful convictions, it is effective to reduce the crime rate, and thus the rate of wrongful accusations, while allowing a higher share of wrongful accusations to become wrongful convictions.

We now seek to examine what is missing from this special case that prevents the model from yielding plausible reasonable doubt thresholds.[49] We consider two changes. First, we allow $\tau > 1$, which provides a greater incentive to avoid wrongful convictions. Second, we allow $\gamma > 0$, which reduces the deterrent effect of lowering d. Although both changes increase $d^*(y)$, Proposition 2 shows that the former is more important:

Proposition 2. *As $\Omega \to 0$ and $\tau \to \infty$ jointly, $d^*(y) \to 1$.*

Proof: See Proof Appendix.

Proposition 2 shows that Blackstone's formulation is necessary for yielding reasonable doubt thresholds comparable to those seen in the United States. In addition, punishments must be sufficiently mild. Mild punishment reduces the deterrent effect of lower reasonable doubt thresholds. In order to avoid wrongful convictions, agents must insist on a high threshold of proof instead. Notably, reasonable doubt thresholds near 1 are possible for any value of γ. Higher values of γ do, however, increase $d^*(y)$.

We next consider how y affects $d^*(y)$.

Proposition 3. *For sufficiently small γ, $d^*(y)$ is decreasing in y.*

Proof: See Proof Appendix.

[47] See Blacktone, W. 1765. *Commentaries on the Laws of England*. Oxford, Clarendon Press.

[48] *Turpin v. Merrell Dow Pharmaceuticals, Inc.*, 959 F.2d 1349, 1357 n. 2 (6th Cir. 1992) (preponderance of the evidence means more than 50%).

[49] Simon (1970) conducts an experiment on undergraduate sociology majors and estimates d^* at around 75%.

There are two effects of y on d. First, as income increases, the marginal utility of consumption lost to crime decreases. This incentivizes wealthier agents to prefer a higher value of d. Second, as income increases, both the crime rate and the potential for being wrongfully convicted decline. This incentivizes wealthier agents to choose a lower value of $d^*(y)$. Proposition 3 shows that the latter effect dominates the former, and wealthier societies require a lower threshold. Lower thresholds of proof and higher income each reduce the equilibrium crime rate, as shown in Proposition 4.

Proposition 4. *For sufficiently small γ, $c(y)$ is decreasing in y.*

Proof: See Proof Appendix.

Finally, we consider the effects of harsher punishments in the model.

Proposition 5. *As Ω increases, $d^*(y)$ decreases.*

Proof: See Proof Appendix.

Proposition 5 contrasts with the major result of Andreoni (1991). In that model, as punishments increase, jurors may employ a higher threshold of proof in order to avoid the increasing disutility from a wrongful conviction. In our model, however, the deterrence motive is stronger because reduced crime, all else equal, reduces the probability of being wrongfully accused.

Our focus is on determining the reasonable doubt threshold for a given punishment. Much of the economics of crime literature, however, focuses on the optimal choice of punishment. Often, as in Becker (1968), the optimal policy is to choose the maximum punishment in order to achieve maximum deterrence. If we allow agents to choose Ω, and if $\gamma = 0$, then our model delivers a similar result where severe punishments can deter all crime. If $\gamma > 0$, however, then it is not possible to deter all criminals and wrongful convictions remain a possibility. Large punishments will thus not generally be optimal. We leave formalizing the joint choice of Ω and d for future research.

5.2 Heterogeneous Society Results

We now consider a society where y is uniformly distributed on the interval $[1, \hat{y}]$ where $\hat{y} > 1$. The main change is that potential criminals now affect the position of the median agent. When choosing their optimal $d(y)$, potential criminals take into account an additional margin; increasing d reduces the probability of their just conviction. It thus follows that they choose a higher reasonable doubt threshold than an agent with a high enough j to never commit crime. Proposition 6 follows:

Proposition 6. *In a heterogeneous society, the societal reasonable doubt standard d^* is higher than in a heterogeneous society with median income, $d^*(\frac{1+\hat{y}}{2})$. It thus follows that the aggregate crime rate, $\frac{1}{\hat{y}-1}\int_1^{\hat{y}} c(y, d^*)dy$ is higher than $c(\frac{1+\hat{y}}{2})$.*

Proof: See Proof Appendix.

Heterogeneous income allows potential criminals to influence the societal standard of reasonable doubt. It follows that income heterogeneity results in excess crime. The empirical literature is divided on whether inequality increases crime. Fajnzylber *et. al.* (2002) find a positive correlation between income inequality, and murders and robberies, and Freeman (1996) presents evidence that inequality increases crime. Kelly (2000), however, finds a similar result for violent crimes, but not property crimes.

5.3 Crime Spillovers

So far, we have assumed that criminals steal only from agents with the same income level and that wrongful accusations are made only against individuals with the same income level as the true culprit. We now alter (A1) and (A2) so that the costs of theft are felt equally throughout a society and all individuals, regardless of income, are equally likely to be wrongfully accused. Theses changes have no effect when analyzing a society with homogeneous income. We thus continue to assume the same distribution of income as section 5.2. The aggregate crime rate now equals:

$$\tilde{c}(\hat{y}) = \frac{1}{\hat{y}-1}\int_1^{\hat{y}} c(y, d^*)dy \tag{11}$$

Agents' utility function is:

$$U(y,p) = r(y + p^* - \tilde{c}(\hat{y})) - jp^* - p^* f(d)\Omega - q(d)\tilde{c}(\hat{y})\tau\Omega \tag{12}$$

The third stage of the game is unaffected. Inserting (7) into (11) and integrating yields:

$$\tilde{c}(\hat{y}) = \gamma + \frac{1-\gamma}{\hat{j}}\left[\frac{ln(\hat{y})}{\hat{y}-1} - \frac{\Omega(1-d^2)}{2(1-\alpha)}\right] \tag{13}$$

Proposition 7 shows that the model's solution is unaffected by these changes.

Proposition 7. *Individuals' and societal doubt standards are identical regardless of whether criminals steal only from those with the same income, or if the effects of crime are evenly distributed throughout society.*

Proof: See Proof Appendix.

5.4 Civil Burdens of Proof

Many legal actions involving theft are pursued as civil matters rather than criminal prosecutions. The civil burden of proof differs in two important ways from the reasonable doubt standard. First, the preponderance of the evidence standard is unambiguously lower.[50] Second, because preponderance of the evidence is widely understood as greater than 50%, its quantitative meaning is made far clearer than that of reasonable doubt.

The first difference is easily explained by the well known idea that Blackstone's formulation is not nearly as strong in civil cases.[51] In our model, this implies a lower value of τ, which results in a lower threshold of proof. The second may be explained by modeling civil cases involving theft.

We now assume that if found guilty (justly or wrongfully), the defendant must pay the victim one unit, the amount of the theft. The utility function thus becomes:

$$U(y,p) = r(y + (1 - f(d))p^* - c(y)(1 - f(d)) - (\tau - 1)c(y)q(d)) - jp^* \tag{14}$$

If $\tau = 1$, then Blackstone's formulation does not apply, agents do not care about being wrongfully found guilty of theft, and they thus choose the lowest possible threshold of proof. This is because they are as likely to benefit from a wrongful conviction (by being awarded one unit) as they are to be harmed (by being ordered to pay one unit).[52] It then follows that the crime rate is:

$$c(y) = \frac{2(1-\alpha) - (1-d^2)}{2(1-\alpha)y\hat{j}} \tag{15}$$

We continue to make distributional assumptions on $\hat{y}$ and $\hat{j}$ to ensure interior solutions and crime rates under 50%. Solving for agents' individual thresholds of proof, we obtain the following result:

Proposition 8. *Individuals' civil thresholds of proof are independent of y.*

Proof: See Proof Appendix.

Proposition 8 provides a novel explanation for why civil burdens of proof are made clearer in the United States than the reasonable doubt standard. Because reasonable doubt thresholds depend

[50] *In re Winship*, 397 U.S. at 371-372 (Harlan, J. concurring).

[51] *Id.* at 371-372 (Harlan, J., concurring) ("the reason for different standards of proof in civil as opposed to criminal litigation [is that] [i]n a civil suit between two private parties for money damages...we view it as no more serious in general for there to be an erroneous verdict in the defendant's favor than for there to be an erroneous verdict in the plaintiff's favor. ... In a criminal case, on the other hand, we do not view the social disutility of convicting an innocent mas as equivalent to the disutility of acquitting someone who is guilty.")

[52] This is similar to Posner's (1998) argument that because civil awards transfer wealth to the victim, the cost of wrongful convictions is less than in criminal cases where punishment yields no direct tangible benefit to the victim.

on income, different communities are allowed to rely on their own standards. But this heterogeneity does not affect the threshold of proof in civil cases so there is no need for ambiguity.

6 Survey

As discussed in the introduction, most efforts at quantifying reasonable doubt consist of asking judges, students, etc. their personal view of what the standard should be. Ideally, juries themselves would be asked to quantify the standard which they employed at trial. Because access to juries is typically limited by local court rules, we chose to survey public defenders in the Commonwealth of Kentucky about the reasonable doubt thresholds that they believe criminal juries actually employ in their regions.[53] As public defenders, these attorneys generally have a high volume of cases, and have a clear professional incentive to accurately understand the thresholds used by juries when determining their clients' fates.

The responses for d^* had a mean of 0.738, a standard deviation of 0.174, a minimum of 0.05, and a maximum of 1. As with other attempts to quantify reasonable doubt, our mean is low compared to widely used scientific levels of confidence such as 90%, 95%, and 99%. The most striking result, however, is the very large standard deviation of the responses. We view this as strong evidence in favor of our argument that reasonable doubt is ill defined and poorly understood, even by those who are highly affected by its true value. We do not believe that that this standard deviation reflects genuine county-wide variation within Kentucky, as demonstrated by dramatic variation within Kentucky counties. In McCracken County, for example, the responses are $[.4, .5, .75, .85]$. In Fayette County, the responses are $[.75, .85, .9., 9, .95]$.

This confusion among trial attorneys about the quantitative value of reasonable doubt has important implications for the legal system. The Supreme Court recently wrote that"ninety-seven percent of federal convictions and ninety-four percent of state convictions are the result of guilty pleas."[54] Plainly, the parties' capacity to accurately identify the community's reasonable doubt threshold will be central to their respective bargaining positions. A prosecutor who overestimates d, for example, may be too quick to offer a defendant a favorable plea bargain. Likewise, a defense attorney who makes the same mistake may be too willing to go to trial and risk a harsher sentence for her client.

We asked the attorneys whether the reasonable doubt threshold changes as jurors become wealth-

[53]The survey was sent to practicing attorneys in the Kentucky Department of Public Advocacy. This organization represents indigent clients in criminal cases throughout the Commonwealth, excluding the Louisville metropolitan area, which uses a different agency. Of about 275 attorneys, 93 responded. The exact questions asked are provided in Appendix A.

[54]See *Missouri v. Frye*, 132 S.Ct. 1399, 1407 (2012)

ier. Table 1 reports the results:

Table 1: Effect of Increasing y on d^*

Answer	#
d^* is unchanged	48 (52%)
d^* decreases	33 (36%)
d^* increases	12 (13%)

Among respondents who believe that wealth affects the threshold of proof, nearly three times as many stated that wealthier juries require a lower threshold of proof than poorer juries. This ratio matches the prediction of Proposition 3.

We also asked the attorneys whether the reasonable doubt threshold depends on the severity of the crime. Table 2 reports the results:

Table 2: Effect of Increasing Ω on d^*

Answer	#
d^* is unchanged	23 (25%)
d^* decreases	35 (38%)
d^* increases	35 (38%)

The survey thus detected no simple relationship between the severity of the crime and the threshold of proof.

Finally, we asked attorneys who practice in different jurisdictions if and why the threshold of proof differs among counties. Several provided anecdotal evidence in favor of our main results, we present a pair of comments:

> There is such a disparity in economic classes in Christian County. Wealthier jurors in Christian just do not understand what so many of our clients go through on a daily basis.

> I also regularly practice in McCracken County. I believe the average juror there requires a lesser degree of proof to find guilt. I believe this is because McCracken County is more segregated in terms of affluence, and that more affluent people there have had a lesser degree of contact with the less fortunate or people who may have had exposure to the legal system. To put it bluntly, a particular Livingston County juror may not be a convicted felon, but almost every one has an uncle, or a cousin, or a friend who has been exposed to the system

Despite our belief that much of the survey's variation results from the lack of clarity regarding reasonable doubt and not genuine county-wide variation, we now regress the mean county level reasonable doubt threshold on a set of economic variables. For income, we use the log of median household income. Survey respondents suggested that population density, education, and the political

environment are also likely to matter. We thus also include the log of population density, the fraction of the population with college degrees, and the fraction of the vote that Barack Obama received in the 2008 U.S. Presidential election. Equation (16) reports the results:

$$d^* = \underset{(1.56)}{1.26} + \underset{(0.53)}{0.05} EDU - \underset{(0.17)}{0.07} ln(INC) - \underset{(0.05)}{0.01} ln(PDEN) + \underset{(0.27)}{0.46} OBAMA + u_t \quad (16)$$

The only variable that is significant with at least 90% confidence is President Obama's share of the vote. The results suggest that politically conservative counties require less proof in order to convict. The sign on income is negative, as predicted by the model, but not statistically significant.

7 Conclusion

The legal system's reluctance to clarify the definition of reasonable doubt is, at first glance, surprising. This paper has demonstrated that, whether by design or accident, this reluctance allows different communities to select different thresholds needed in order to convict. Specifically, wealthier communities and those with more income homogeneity require less evidence in order to return a guilty verdict.

The threshold needed to convict is of interest to any party in a criminal trial, including the defense attorney, the prosecutor, and the accused. Our analysis has focused on only income's effect on reasonable doubt. It would be of interest to examine the impact of other demographic differences on the reasonable doubt threshold. Race, in particular, is worthy of additional study. Our model can be extended so that members of one racial group are more likely to be wrongfully accused if a crime is committed by a fellow member of that group. Likewise, if different racial groups have different levels of income, we expect that they will be impacted by crime differently. The model can then examine how racial diversity affects the reasonable doubt threshold, and the rates of wrongful convictions in different groups. These questions are left for future research.

Proof Appendix

Proof of Proposition 1: Equation (10) may be rewritten as follows:

$$-\frac{\tau^{-1}d(1-\gamma)}{y} + (1-d)\left[+\gamma\hat{j} + \frac{1-\gamma}{y}\right] = (1-d)\left[\frac{(1-\gamma)\Omega(1-d^2)}{2(1-\alpha)}\right] + \frac{d(1-d)^2\Omega}{2(1-\alpha)} \quad (17)$$

Suppose that a doubt threshold, denoted $\tilde{d} \geq \frac{1}{1+\tau^{-1}}$ exists.

The right hand side of (17) is positive for all $d \in (\alpha, 1)$. The left hand side evaluated at $\tilde{d}$ equals $\frac{(1-\gamma)\left[1-\tilde{d}(1+\tau^{-1})\right]}{y} + (1-\tilde{d})\gamma\hat{j}$. For any such $\tilde{d}$, the left hand side is negative for sufficiently small γ.

It follows that such a $\tilde{d}$ can never be the solution to (10). Thus $d^*(y) < \frac{1}{1+\tau^{-1}}$. It then follows that if $\tau = 1$ and $\gamma = 0$, then $d^*(y) < \frac{1}{2}$ ■

Proof of Proposition 2: Evaluating (10) at $\Omega = 0$ and $\tau^{-1} = 0$, $\frac{\partial U(y,p)}{\partial d} > 0 \; \forall \; d < 1$. ■

Proof of Proposition 3: Differentiating (10) with respect to y yields:

$$\frac{\partial^2 U(y,p)}{\partial d \partial y} = \frac{(1-\gamma)(d(1+\tau^{-1})-1)}{y^2} \tag{18}$$

It follows from the concavity of $U(y,p)$ and (18) that $d^*(y)$ is increasing in y if and only if $d^*(y) > \frac{1}{1+\tau^{-1}} > \frac{1}{2}$. Proposition 1, however, established that such a $d^*(y)$ cannot exist and it must be the case that $d^*(y)$ is decreasing in y for sufficiently small γ. ■

Proof of Proposition 4: Using Equation (7), $c(y)$ is increasing in d and decreasing in y. It follows that $c(y)$ is decreasing in y if $d^*(y)$ is also decreasing in y, which is established by Proposition 3 for sufficiently small γ. ■

Proof of Proposition 5: It is direct to verify that $\frac{\partial^2 U(y,p)}{\partial d \partial \Omega} < 0$. Using the concavity of $U(y,p)$, higher values of Ω induce lower values of $d^*(y)$. ■

Proof of Proposition 6: (A5) ensures that $c(y) > 0 \; \forall \; y$. Because crime rates are always positive, it follows, that for any y, there exists a sufficiently low j such that for $d^*(y)$, $p^*(y,j) = 1$. Some agents will choose to commit a crime at the heterogeneous society level of reasonable doubt.[55] Consider such an agent's reasonable doubt choice. Assuming that she plans to commit a crime, her first-order condition becomes:

$$-\frac{\tau^{-1}d(1-\gamma)}{y} + (1-d)\left[+\gamma + \frac{1-\gamma}{y} - \frac{(1-\gamma)\Omega(1-d^2)}{2(1-\alpha)}\right] - \frac{d(1-d)^2\Omega}{2(1-\alpha)} = -\frac{d\Omega}{1-\alpha} \tag{19}$$

The left hand side of (19) is identical to that of (9). Denoting $\hat{d}(y)$ as the criminal's reasonable doubt threshold that solves (19), the concavity of utility function ensures that $\hat{d}(y) > d^*(y)$. A criminal has an additional margin. Increasing d reduces her probability of being justly convicted.

Proposition 3 establishes that $d^*(y)$ is decreasing in y. Now suppose that, with y uniformly distributed on the interval $[1, \hat{y}]$ with $\hat{y} > 1$, the median agent's preference is $d^*(\frac{1+\hat{y}}{2})$. It then follows

[55] In addition to these agents, there are also agents who would not commit a crime at $d^*(y)$ but who nonetheless prefer a higher value of d that induces them to steal. Their existence does not, however, affect the proof.

that $\forall\ q < \frac{1+\hat{y}}{2}$, $d^*(q) > d^*(\frac{1+\hat{y}}{2})$ and half of all agents prefer a higher reasonable doubt threshold. By the continuity of 19, for sufficiently small $\epsilon > 0$, there exists some criminal for whom $d^{'}(\frac{1+\hat{y}}{2} + \epsilon) > d^*(\frac{1+\hat{y}}{2})$. A majority of agents thus prefer a higher societal reasonable doubt threshold than $d^*(\frac{1+\hat{y}}{2})$.

Finally, it is direct from (11) that the higher reasonable doubt threshold results in a higher crime rate than if the societal threshold were that of a heterogeneous society with the median income. ■

Proof of Proposition 7: Differentiating (13) with respect to d yields $\tilde{c}_d(y) = c_d(y) = \frac{2d\Omega}{1-\alpha}$. It then follows that agents' first-order condition is unchanged, and that their choice of $d^*(y)$ is unaffected. ■

Proof of Proposition 8: Differentiating (14) with respect to y yields:

$$-c_d(y)(1 - f(d)) + f_d(y)c(y) - (\tau - 1)[c_d(y)q(d) + q_d(y)c(y)] = 0 \tag{20}$$

It is direct to verify that y may be eliminated from (20) and that the reasonable doubt threshold thus does not depend on y. ■

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Appendix A

Survey Sent to Kentucky Public Defenders

From time to time, we want to take advantage of the depth and breadth of knowledge afforded by the experts (you) within the statewide public defender system to hopefully develop information that will help our clients through better rules, statutes, or policies in the future. I come to you today with one of those opportunities, relating to the reasonable doubt standard or proof. Please take a minute and answer the five-question survey that appears here.

Question 1: In which county do you practice most?

Question 2: Please set aside your own opinion of what "reasonable doubt" means. Instead, think about the average juror in the county where you practice most. On a scale of 0% to 100% – 0% meaning absolutely sure of innocence, and 100% meaning absolutely sure of guilt – how sure do you believe that the average juror in the jurisdiction where you practice most would have to be in order to convict a defendant accused of stealing $500 from his neighbor (a Class D felony)?

Question 3: Do you think your answer to Question 2 would change if the average juror in the county where you practice most became wealthier?
1. No, my answer would stay the same.
2. Yes, on average, wealthier jurors require greater certainty about the defendant's guilt before convicting.
3. Yes, on average, wealthier jurors require less certainty about the defendant's guilt before convicting.

Question 4: Do you think your answer to Question 2 would change depending on the severity of the crime?
1. No, my answer would stay the same.
2. Yes, the average juror requires greater certainty about the defendant's guilt as the severity of the crime increases.
3. Yes, the average juror requires less certainty about the defendant's guilt as the severity of the crime increases.

Question 5: If you frequently practice in more than one county, do you think that the answer to Question 2 is different for different counties? If so, why do you think that is?