Everybody Stay Cool, This Is a Robbery*

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Abstract

Data aggregation across time and space, and endogeneity of crime policies have rendered identification of Becker's model of criminal behavior quite arduous. This paper uses unique data on the benefits of individual crimes, in particular, 5,000 Italian bank robberies – representing 57 percent of all European bank robberies – to identify deterrence, and, for the first time, the criminal's perceived disutility of jail. Bank robbers behave according to an instantaneous version of Becker's model of crime: during bank robberies, both, the probability of apprehension and the average haul increase over time. Unique data on the chosen length (in minutes) of successful and unsuccessful bank robberies allow me to test the rationality of criminal behavior. Based on a simple model of optimal duration of bank robberies I obtain the distribution of criminals' disutility of ending up in jail. Consistent with the disutility representing an opportunity cost (more able criminals should be less willing to end up in jail), its distribution is positively skewed and resembles a typical earnings distribution. This result suggests that small scale anti-poverty programs might lead to a substantial reduction in bank robberies. Moreover, the relationship between the *modus operandi* of bank robberies and the derived disutility of jail time is consistent with the existence of general deterrence. Bank robbers appear to be not only well informed about specific sentence enhancements that are spelled out in the Italian penal code, but also to know the typical sentencing done by the judges.

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1 Introduction

According to the Uniform Crime Statistics each year in the U.S. there are around 10,000 bank robberies, representing more than 10 percent of all commercial robberies; with losses averaging 4,000 dollars Weisel (2007). Relative to the size of the country, the situation in Italy is worse. There are more bank robberies in Italy than in the rest of Europe altogether. In order to fight these crimes it is of uttermost importance to understand criminal behavior. The aim of this paper is to shed light on the criminal strategies used during robberies, and to relate them to the criminals' fear of jail.

Based on unique data of individual Italian bank robberies organized between between 2005 and 2007 and on an the assumption of rational criminal behavior this paper finds that criminals respond to incentives set by the sanctioning system. Robbing a bank with a masquerade, or in group, or by the use of firearms leads to sentence enhancements. But these modus operandi influence also the likelihood of being caught and the expected haul. Analyzing these trade-offs within a model of optimal duration of the bank robbery I find that criminals take Italy's sanctioning rules into account when a robbery is planned.

Harshening the sanctions would thus be one way to reduce Italy's dramatic number of bank robberies. I also estimate the criminals' disutility of apprehension. There is heterogeneity in the criminals' "fear of jail," which might depend on how much they discount the future (DiIulio, 1996), or on their opportunity cost of spending their time in jail. For this reason, more able criminals are expected to dislike prison time more than less able ones.

This paper's modeling builds on a simple model of the crime. Such a model predicts that criminals commit an additional crime whenever the expected marginal utility that they derive from the crime is larger than the expected marginal sanction. Richard Freeman in his Labor Economics Handbook Chapter "The Economics of Crime" formalizes a discrete version of this model. He defines W_c to be the gain from successful crime, p

the probability of being apprehended, S the extent of punishment, and W earnings from legitimate work. The criminal chooses to commit a crime in a given time period rather than do legitimate work when:

$$(1-p)U(W_c) - pU(S) > U(W) \; . \tag{1}$$

Even though the model is simple and intuitive it has been difficult to estimate. The data available to researchers are typically aggregated across space and time, which makes it difficult to measure legal and illegal earnings (Vicusi, 1986b). Measurement error have plagued the measurement of W_c and simultaneity issues (policy makers increase police enforcement and the severity of sanctions when crime levels are high) have made the estimation of the deterrence effect of the probability of apprehension p impossible without an instrument. Moreover, extensions to the model that would increase its realism–such as additional allocations of time, the effect of crime or apprehension in one period on future legitimate and criminal earnings, the risk that a criminal is victimized by other criminals, the degree of social stigma for crime, and, perhaps, the possibility that crime and legal work are not exclusionary acts–complicate the estimation even further.

Some studies have estimated Eq. 1 using individual level data on perceived deterrence but these data are usually based on prison surveys (Peterson et al., 1980), or on other self-reported crime data (Grogger, 1998, Glaeser and Sacerdote, 1999).[1] In both surveys self-reported crime activities might be subject to untruthful reporting or at least to underreporting (Vicusi, 1986a). Kessler and Levitt (1999) use the introduction of sentence enhancement while Helland and Tabarrok (2007) use a quasi-randomization of sentence enhancements to isolate deterrence and find strong evidence of it. Lee and McCrary (2005), instead, find very little evidence of deterrence among juvenile criminals who move to the adult sanctioning system: their criminal behavior changes very little upon turn-

[1] Nagin (1998) and Cameron (1988) survey the literature on deterrence.

ing 18. Drago et al. (2009) use an Italian quasi-experimental setting and find evidence of deterrence. All these studies estimate average deterrence effects. In this paper I try to go beyond just estimating the average deterrence effect by backing out, under some parametric assumptions, the distribution of criminals' disutility of jail time. This paper shows that bank robbers face an instantaneous version of the tradeoff modeled below in Eq. 1. I can then use rationality and some structural assumptions to solve for the only unknown part that determines the modus operandi of bank robberies, i.e. the disutility of jail time. The distribution of disutility of jail time is positively skewed and resembles the earnings distribution. This results suggests that small scale anti-poverty programs might lead to a substantial reduction in bank robberies.

2 Italian Bank Robberies and the Data

Fifty-seven percent of Europe's bank robberies happen in Italy (Kington, 2007). Italy experiences more than 3,000 bank robberies every year. As a comparison the US has more than 5 times the population of Italy but just 3 times as many bank robberies (Weisel, 2007). Figure 1 shows the average haul (right axis) and the number of bank robberies (left axis) between 1990 and 2003. While the average haul has been going down, the number of bank robberies were around 1,500 in the early 90s and almost double that number 10 years later. Not only the amount robbed is lower now than it used to be, also the number of deaths involved has plummeted after the 1991 peak of 17 deaths.

One reason why Italy has so many bank robberies is that approximately 90 percent of them are successful and even a larger fraction end up without an arrest, while in the U.S. 33 percent of bank robbers are arrested on the same day they commit the robbery. Also, US federal guidelines impose sentences of *at least* 20 years (plus 5 years when a weapon is used), while in Italy the sentence length ranges between 3 and 10 years depending on the severity of the crime. Thus the minimum sentence is significantly lower. The range may become 4.5 years to 20 years only when at least one of the following conditions is satisfied (art. 628 of the penal code): a weapon is used; the robber is masked, or he is not alone; violence is used to incapacitate a victim; the criminals belong to an organized crime association.[2]

Robbing a bank seems to pay. The average haul is 20,000 euro. This leads to a direct cost for society that is more than 57 million euro each year. But the indirect cost is even larger. A survey of 21,000 retail bank branches representing 65 percent of all Italian branches shows that in 2006 banks spent for each branch an average of 10,700 euro to prevent bank robberies (a total of more than 300 million euro (OSSIF, 2006)). Each branch spent an additional 4,900 euro to prevent thefts and 6,300 euro to protect financial couriers. The total amount spent by banks in 2006 to prevent thefts and robberies was more than 700 million euro. This might in part explain why in Europe Italian bank charge on average the largest account management fees: 90 euro against a European average of just 14 euro (EC, 2007). Moreover, Miller-Burke et al. (1999) show that in the U.S. most employees have multiple negative health consequences from experiencing a bank robbery while at work, including anxiety and post-traumatic stress disorder. This is unlikely to be very different in Italy and generates an additional cost.

Despite these frightening numbers, there is to the best of my knowledge almost no empirical research in economics and very little research in criminology that has tried to

[2]The exact wording of art. 628, Rapina is: Chiunque, per procurare a se' o ad altri un ingiusto profitto *(unjust profit)*, mediante violenza *(violence)* alla persona o minaccia, s'impossessa della cosa mobile altrui, sottraendola a chi la detiene, e' punito con la reclusione da tre a dieci anni *(three to ten years)* e con la multa da lire un milione a quattro milioni.

Alla stessa pena soggiace chi adopera violenza o minaccia immediatamente dopo la sottrazione per assicurare a se' o ad altri il possesso della cosa sottratta, o per procurare a se' o ad altri l'impunita'.

La pena e' della reclusione da quattro anni e sei mesi a venti anni *(four years and 6 months to twenty years)* e della multa da lire due milioni a lire sei milioni:

1) se la violenza o minaccia e' commessa con armi *(weapons)*, o da persona travisata *(masked)*, o da piu' persone riunite *(in groups)*;

2) se la violenza consiste nel porre taluno in stato d'incapacita' di volere o di agire *(violence is used to incapacitate a victim)*;

3) se la violenza o minaccia e' posta in essere da persona che fa parte dell'associazione di cui all'articolo 416 bis (1) *(organized crime)*.

study bank robberies using robbery-level data. One reason for this is certainly the lack of data. Several studies describe in great detail robberies (Cook, 2009, 1990, 1987, 1986, 1985) and bank robberies in particular (FBI, 2007, Weisel, 2007, Baumer and Carrington, 1986), but only one study tries to test deterrence explicitly using data on bank robberies, and banks' security devices, Hannan (1982). The major shortcoming of this study is that the adoption of new security devices depends on past robberies, thus introducing an endogeneity that might explain why the author finds no significant effects of the presence of security devices on robberies.

I have been granted access to some unique data: the universe of single bank robberies perpetrated in Italy between 2005 and 2007. The data are divided into 2 parts: robbery-level data and branch-level data. After each robbery branch managers need to fill out a survey describing the facts (i.e number of bank robbers, haul, weapons, technique, etc.).

The median duration of bank robberies is three minutes. Table 1 shows the distribution of bank robbery durations, and the corresponding number of arrests truncated at 30 minutes. Truncating the distribution at half an hour excludes 5 percent of robberies. The distribution shows that after the 9th minute heaping might be an issue. Reporting 10, 15, 20, 25, 30 minute robberies is considerably more likely than reporting numbers that are not multiple of 5. Below 9 minutes only 5 minutes seems to be a little over-represented. Truncating the distribution at 9 minutes I exclude 861 observations out of 6,446, so a little more than 10 percent of the robberies.[3]

The summary statistics in Table 2 show that between 2005 and 2007 in our sample only 5.8 percent of bank robbers were arrested after robberies that lasted less than 9 minutes.[4] The typical robbery lasts around 3.2 minutes and leads to a haul of 14,000 euros, larger than the average of $8,000 in the US. Given that more than half of all bank

[3] As a robustness check I've used the whole sample with interval-censoring to solve the heaping problem, and results are very similar. The results are available upon request.

[4] Fifty-nine percent of these arrests happen during the bank robbery, while the rest happens afterwards. The results are robust to the exclusion of those arrests that do not happen immediately.

robberies involve more than just one criminal the average haul per criminal is smaller and equal to almost 8,000 euros. Only 14 percent of bank robberies involve firearms, as judges sanction their use with increased punishments. Around 50 percent of all bank robbers mask their face when robbing a bank. 22 percent of bank robberies happen in the Center of Italy, 30 percent in the South and the rest in the North.[5] Bank robbers are more likely to chose banks that have on average smaller amounts of cash and banks that are located in isolation.

The data are rich with information about the security devices installed in the bank. I know their type and their characteristics. I summarize this information by counting the number of different devices that each bank has, and compute how many characteristics these devices have in each bank on average for each device. For example, 92 percent of banks have a special entrance to the bank but the characteristics differ widely. Some have metal detectors, others have a double door where people can be trapped, others have a biometric sensor, etc., while other entrances might display all these characteristics. Robbed banks tend to have more security devices installed than the average bank (7.2 versus 6.7), and these devices tend to have more characteristics per device. The main reason for this is that banks tend to install new devices after they experience a bank robbery. The majority of these devices are not visible to the criminal (like automatic banknote distributors, banknote spotters, time-delayers, banknote tracing devices, vaults, and alarm systems) while 33 percent are clearly visible (like metal detectors, vault's time-locks, and protected teller's post). Since visible and invisible devices might have a different impact on the robbery I will control for the fraction of invisible devices.

[5]The following central regions separate the southern regions from the northern ones: Lazio, Marche, Toscana, Molise, and Umbria.

3 A Continuous Time Version of Becker's Model of Crime

Conditional on having chosen to rob a bank the criminal's expected utility $V(t,x,z)$ is a function of the duration of the bank robbery, the characteristics of the bank z, and the bank robbers' *modus operandi* x:

$$\begin{aligned} V(t,x,z) &= [1 - P(T < t|x,z)]E(Y|d=0,t,x,z) - P(T < t|x,z)D \\ &= [1 - F(t|x,z)]E(Y|d=0,t,x,z) - F(t|x,z)D, \end{aligned} \tag{2}$$

where $P(T < t|x,z) = F(t|x,z)$ represents the probability of apprehension before time t, $E(Y|d=0,t,x,z)$ represents the expected haul by successful robbers ($d=0$), which also depends on the duration of the robbery. D represents the *unobserved* disutility from apprehension.

Given that once the bank robbers enter a bank both x and z are given, the bank robber has to chose how long to stay inside the bank. The optimal duration of a bank robbery t^*, given specific characteristics of the bank and of the bank robbers, solves

$$-F'(t^*)[E(Y|t^*,\cdot) + D] + [1 - F(t^*|\cdot)]E'(Y|t^*,\cdot) = 0.^{6} \tag{3}$$

I use a unique dataset of bank robberies to test the rationality of criminal behavior by estimating equation 3. Moreover, solving the first order condition for the disutility of apprehension D gives

$$\begin{aligned} D(t^*,x,z) &= \frac{1 - F(t^*|\cdot)}{F'(t^*|\cdot)}E'(Y|t^*,\cdot) - E(Y|t^*,\cdot) \\ &= \frac{1}{\lambda(t^*|x,z)}E'(Y|t^*,x,z) - E(Y|t^*,x,z). \end{aligned} \tag{4}$$

Estimates of $\lambda(t^*|x,z)$, $E'(Y|t^*,x,z)$ and $E(Y|t^*,x,z)$ provide the distribution of the disutility of apprehension, a measures of the heterogeneity of criminal behavior. It is clear that the precision of the estimates depends on how precisely bank managers measure the duration of bank robberies t. Later, as a robustness check, I determine how robust the results are to measurement error in t.

These valuations are needed to evaluate more comprehensively the cost and benefits of various aspects of the criminal justice.[7] [8]

4 Empirical Analysis of Preferences and Strategies of Bank Robbers

4.1 The Average and the Marginal Haul

Equation 4 shows that the disutility of incarceration depends on the marginal haul $E'(t)$, on the average haul $E(t)$, and on the hazard rate of apprehension $\lambda(t)$. Figure 2 shows that using a locally smoothed regression with optimal bandwidth (Cleveland, 1979) the average haul as a function of time is approximately linear.[9] The linear regression, clearly a good approximation of the more flexible conditional mean, has the advantage of delivering both $E'(t^*) = \beta$ and $E(t^*) = t^*\beta$ at once. Moreover, a liner regression allows me to estimate group specific marginal effects without suffering from the curse of dimensionality typical of more non-parametric methods. Using a linear model and allowing the slope of the haul with respect to t to depend on x the vector of the *modus operandi* x and of the branch

[7]Barbarino and Mastrobuoni (2008), for example, use the value of statistical life estimated by the European Commission to evaluate the social cost of Italian pardons. Since victims are often the criminals themselves, if criminals value their life differently than the average person the authors might over or understate the social cost for the society.

[8]Levitt and Venkatesh (2000) report a variety of approaches to measuring the implied value of life for the gang members; none of the estimates are greater than \$100,000, which is an order of magnitude lower than the typical estimate obtained for the general population.

[9]Sixty durations were smaller than one minute and have been rounded to one minute.

characteristics z the estimating equation is:

$$y_i = \alpha + \beta'_w w_i + \beta_{t^*} t^*_i + \beta'_{t^* w} w_i t^*_i + \epsilon_i \tag{5}$$

where $w_i = (x_i \; z_i)$. Notice that the purpose of this equation is to provide the *best linear predictor* of the haul, without any considerations about causality. Indeed, most of the coefficients are likely to reflect the selection on ability, which is exactly what the model is supposed to isolate.

Table 3 presents the estimates of Eq. 5.[10] Column 1 shows that when I do not control for any other characteristics of either the bank, or the bank robbery, each additional minute spent robbing a bank increases the haul by an average of approximately 1,000 euro but, as we will see later, it also increases the probability of apprehension. In column 2 I allow the conditional mean $E(t)$ but not the marginal effect $E'(t)$ to depend on the characteristics of the bank robbery. Using firearms increases the average haul substantially (4,400 euro), and so does being masked (2,000 euro), which is probably a signal of ability and professionalism. Operating in groups, instead, seems to lower the per-capita haul. In column 3 these same variables are interacted with the duration of the bank robbery, allowing for differential slopes. All slopes stay positive, though having a firearm seems to be the only variable that increases the marginal effect significantly. In column 4 and 5 I add all the available controls, with and without interacting each control with the duration of the bank robbery. Column 6 shows that bank robberies in the South and in the Center of Italy have average hauls that are on approximately 1,500 euro larger than in the North. Isolated banks and banks with lower amounts of cash bring lower hauls (-300 euro and - 1,300 euro respectively). Smaller banks, that is banks with less than 5 employees, reduce the haul by an average of 300 euro. Security devices seem to payoff. Each additional security device reduces the average haul by 248 euro, and adding an

[10] Notice that using haul as the dependent variable I am implicitly assuming a linear utility model.

additional characteristic to all security devices reduces the haul by 2,500 euro. I higher fraction of invisible security devices does also reduce the expected haul. Banks that are guarded have are subject to lower hauls, but the difference is not significantly different from zero. When I interact the duration with all these variables many of these coefficients stop being significant (column 5). The slope does depend significantly on firearms (+1,600 euro), on the average number of characteristics per security device (-1500 euro), and small cash holdings (-800 euro). The last column presents the specification that I use to predict the haul and the marginal haul per minute. In order to have a robust estimate of the slope I condition on the interactions that are significantly different from zero.

4.2 The Hazard Rate of Arrest

But as the model has shown, the benefits are only part of the story. Criminals are sometimes arrested, and might serve prison time. Figure 4 shows the estimated unconditional hazard rate, $\lambda(t)$, when six different distributions are used: exponential (constant), Weibull, Gompertz, log-logistic, log-normal, generalized gamma.[11] Apart from the trivial constant case of the exponential hazard, the estimated hazard functions are all increasing over time, indicating that the probability of getting caught at time t conditional on not having been caught at time $t-1$ is increasing over time. Table 4 shows that in terms of the AIC model selection criteria, this time conditional on the same observable characteristics used when modeling the expected haul, the log-normal model is slightly preferred to the gamma one and to the log-logistic one, though without penalizing the use of additional degrees of freedom, so just based on the likelihood, the gamma model is slightly preferred to other ones. From now on I focus on the lognormal and on the gamma model, though the other model give very similar results.[12]

[11] In Table 1 and in the hazard models successful robberies are treated as censored. Given that censoring might not be exogenous one can estimate the hazard rates using a competing hazard model, where success competes with arrest and than estimate the hazard. Results are robust to this alternative specification.

[12] The results are also robust to frailty models that allow for unobserved heterogeneity.

Table 5 shows how the same regressors that I used for $E(t)$ influence $\lambda(t)$ based on Cox's proportional hazard model. In such model the coefficients do not depend on the baseline hazard.[13] Notice that the purpose is again to estimate the best predictor of the hazard rate and not to infer causality. As before most of the effects are likely to be driven by selection. In column 1 and 2 I control for the characteristics of the robbery and for the region, while in column 3 I additionally control for the characteristics of the bank. Focusing on the comprehensive regression, criminals who use firearms are less likely to get arrested, and so do robbers who work in groups. Robbers who work in groups are likely to monitor the street, and to realize possible dangers. The geographic region does not influence the hazard, while smaller and more isolated banks tend to be safer. The number of security devices has a puzzling negative effect, while the average number of characteristics does not seem to affect the hazard in any significant way. Conditional on the other covariates whether the bank has a guard or not does not seem to matter.

4.3 The Disutility of Apprehension

After estimating $E(t, x, z)$, $E'(t, x, z)$, and $\lambda(t, x, z)$ Eq. 4 determines the disutility of apprehension. In order to compute the "yearly" disutility of apprehension I collected data on sentences related to bank robberies.[14]

4.3.1 The expected sentence length

Table 6 shows the summary statistics for the sample of 325 bank robberies attributed to 97 different bank robbers who were sentenced to jail between 2005 and 2007. This means that in our sample each robber has been judged based on an average of 3.4 bank robberies. The bank robbers are on average 35 years old, most are Italian (92 percent), and despite

[13] All the parametric hazard function give results that are very similar to the Cox model.

[14] In Italy there are no official statistics on prison time served by convicted bank robbers. The collected data are based on 325 bank robberies committed between 1993 and 2007.

the data being based on the Tribunal of Turin (the 2nd largest city in the north of Italy) 35 percent were born in the South of Italy. 67 percent of the robbers are recidivists, and 34 percent plea bargain. The other variables vary by robbery. 22.5 percent of the robberies are done using firearms (versus 13.7 percent from the OSSIF data), 57.2 percent of robbers use masks (versus 42.7 percent) and 68.9 percent work in groups (versus 66.3 percent). 4 percent of the time the robber uses hostages. The average total haul is 12,374 Euro, slightly lower than the total haul based on the banking data. Even though the modus operandi of robbers that were sentenced are on average not exactly the same as for the sample of robberies based on the bank data, there is no reason why the determinants of the sentence length should be any different.

Figure 3 shows the density of the yearly sentence length, both using a histogram and a kernel estimator. The average sentence length is 3.4 years in prison. The distribution is skewed to the right. Data on sentence durations allows me to model the log-sentence length based on the same $modus operandi$ variables observed for the bank robberies and to impute the variation in the log-Disutility of apprehension, D, that is driven by the variation in the sentence length, S, $log(D) = log(d) + log(S)$. Thus $log(D) - log(S) = log(d)$ represents the log-Disutility for each year in jail.

In order to determine the way the modus operandi shapes the expected sentence length in table 7 I regress the log-sentence length on whether the robber used a firearms, was masked, or worked in groups. Using a firearm increases the sentence by approximately 50 percent after controlling for another set of controls (recidivism, used hostages, plead bargain, year, total number of robberies committed, total haul). Using a mask and working in groups has a smaller effect on the sentence. Working in groups increases the sentence length by approximately 30 percent, and being masked by 15 percent but without being statistically different from zero. A plea bargain reduces the sentence duration by 20 percent.

4.3.2 The total and the yearly disutility of apprehension

Figure 5 shows for those criminals who were not arrested and whose choice of t was unconstraint the distribution of the total disutility of apprehension truncated at 250,000 euro and the yearly one truncated at 150,000 euro. For 10 percent of the robberies the model predicts negative disutilities of ending up in jail. This is entirely driven by those criminals who rob banks with a large average number of characteristics per security device. These criminals have such small marginal hauls that the disutility ends up being negative. The kernel densities show that the expected sentence length reduces the heterogeneity in disutility: the yearly figures are more concentrated than the total ones.

Table 8 shows the corresponding summary statistics, this time without truncating. The distribution is highly right-skewed. As a consequence the median is small compared to the mean: 20,000 against 60,000 euro for the total figure. This amount of heterogeneity is quite large and can only in part be explained by different expected sentences. Differences in sentences explain 10 percent of the variation in of the disutility of apprehension[15] though they do reduce inequality, based on the coefficient of variation, by 20 percent. The yearly average disutlity is approximately 16,000 euro and the median is 7,000 euro. Since expected sentences are likely to be measured with some noise (it is hard to know what robbers really expect to spend in jail), they could potentially explain a larger share of the variation.

4.3.3 Disutility of apprehension: ability vs. deterrence

How does the disutility of jail depend on the characteristics of the bank, and of the *modus operandi*? One way to asses this is to take the derivative of the disutility with respect to the same variables that we saw determine the haul and the risk of arrest. Given that D differs across individuals so will its derivative.

[15]This value can be derived by the difference between 1 and the R-squared of a regression of the total disutility on the yearly one.

Table 9 shows the the derivative of $\log D(t, x, z)$ with respect to duration t, *modus operandi* x, and branch characteristics z. In order to asses the level of significance of the derivatives I bootstrap 100 times the model 100 times, computing 100 average derivatives (averaged over the bootstrap sample of robberies). The Table shows the average "average" derivative, its standard deviation, and the 5th and 95th percentile. Whenever the 5th and the 95th percentile have different signs the average derivative is not different from zero at the 10 percent level of significance.

The sanctioning rules (judges adjust sentences proportionally to the aggravation of the robbery) suggest to use the log value of freedom instead of the level.[16] The observable characteristics of banks and bank robberies change the (log) value of freedom the way we would expect given the sanctioning rules set by the penal code. Art 628 of the penal code sanctions masked robberies, robberies perpetrated by more than one criminal, and robberies where firearms are used more than "simple" robberies (*rapina semplice*). These deterrence effects are clearly visible in Table 9. The use of firearms leads to an increase in the disutility of apprehension of about 136 percent. Using masks and operating in group leads to a similar increase in disutility (87 to 160 percent). All these derivatives are significantly larger than zero. But this increase is considerably larger than the corresponding increase in the sentence length, suggesting that criminals that use firearms, work in groups, and mask themselves do not only fear longer sentences, but are also of higher ability. The heterogeneity in ability is clearly visible when I derive the disutility with respect to variables that do not influence the sentence length.

Bank robbers who operate against banks with little cash holdings are of substantially lower ability (they do not chose the right banks, which is certainly an important part of a bank robbery) while those that choose banks with less than 5 employees tend to be of higher ability. While the first part is driven by the money, the second part is driven by robberies in smaller banks being less risky. Employees need to be monitored; the

[16] Using the disutility of apprehension in levels gives very similar results.

more there are, the riskier the robbery becomes. Security devices, instead, generate an ambiguous selection. While only the more able criminals select banks with more security devices, the same is not true for the average number of characteristics. While the fraction of visible devices does not significantly alter the selection of criminals.

The duration of the bank robbery is a clear predictor of the criminals value of freedom. Those who value freedom organize very short robberies, as the value of freedom of the criminals decreases by 10 percent for every additional minute spent robbing the bank.

4.3.4 How does measurement error in duration change the distribution of D?

While measurement error in the duration is going to have little effect on the estimated hazard rate, simply because the parametric baseline is going to smooth over the measurement error, the same is not true for the marginal and for the average haul. For the haul (Eq. 5) the duration represents a covariate, and measurement is going to induce a downward bias. Some simulations that I performed show that while rounding a duration measured in seconds to the nearest or to the smallest minute has almost no effect on the coefficient of duration (chosen to have the same level of significance as in the actual data), rounding the duration randomly to one of the two nearest minutes induces a larger bias (-13 percent). The largest bias (-16 percent) arises when 10 percent of the durations are randomly set to be equal to 5 minutes.

The relative bias of size m is going to induce a change in D that is equal to:

$$m \frac{\partial D_i}{\partial \log \beta_i} = m \frac{\beta_i (1 - t_i^* \lambda(t_i^*, x_i))}{\lambda(t_i^*, x_i)} \tag{6}$$

where $\beta_i = \beta_{t^*} t_i^* + \beta'_{t^* w} w_i t_i^*$ represents the individual slope with respect to t. Since $1 - t_i^* \lambda(t_i^*, x_i)$ is generally positive the bias reduces the estimated D. This can clearly be seen in Figure 6, where I plot the density of D assuming three different biases: a 10, 20, and 30 percent attenuation bias of the slope.

4.3.5 How much deterrence is needed to eliminate bank robberies?

The structural model allows us to answer the following question: How much would we need to increase the disutility of jail to drive the number of bank robberies to zero? In terms of the model, one just needs to determine the level of disutility that corresponds to an optimal duration that is equal to zero:

$$D(0, x, z) = \frac{1}{\lambda(0|x, z)} E'(Y|0, x, z) - E(Y|0, x, z). \tag{7}$$

$\log D(0, x, z) - \log D(t^*, x, z)$ will simply represent the percentage increase in disutility needed for robbers that use a *modus operandi* x, and rob banks of type z, in t^* minutes to drive the duration to 0. Table 11 shows the distribution of the changes. The 5th percentile shows that without correcting for measurement error in order to drive 5 percent of the sample to a duration of zero one needs a 3 percent increase in the total disutility of jail, or equivalently the same increase in sentence length. Controlling for measurement error bias the change in penalty needed is even smaller. In order to reduce the bank robberies by a quarter the penalties would have to increase by between 9 and 13 percent, depending on the degree of the bias. To curb robberies by one-half penalties would have to increase by between 19 and 32 percent. In order to almost eliminate bank robberies (-95 percent) the sanctions would have to increase by 181 percent in the absence of measurement error and by 91 percent if the measurement bias was equal to 30 percent. Overall, the estimated model predicts criminal behavior to be highly responsive to changes in the sanctioning system.

5 Conclusions

Based on unique data on individual bank robberies perpetrated in Italy between 2005 and 2007 this paper isolates the criminals' disutility of apprehension and estimates its distribution. The grand majority of criminals face low disutilities of apprehension while a few face very high ones. The shape of the distribution resembles the shape of an earnings distribution. This skewness suggests that anti-poverty measures targeted toward potential low-skilled criminals might lead to a reduction in the number of bank robberies.

I find evidence which is consistent with highly attentive criminals, who know the incentives set by the sanctioning system. Aggravating characteristics of the robberies increase the disutility of apprehension. Harshening the sanctions against bank robbers might thus be one way to reduce Italy's dramatic number of bank robberies–there are more bank robberies in Italy than in the rest of Europe altogether. Indeed, I find that crime is very responsive to penalties. A simulation based on the model shows that in order to reduce the number of bank robberies by 50 percent the expected sentence length would have to be increased only by 32 percent.

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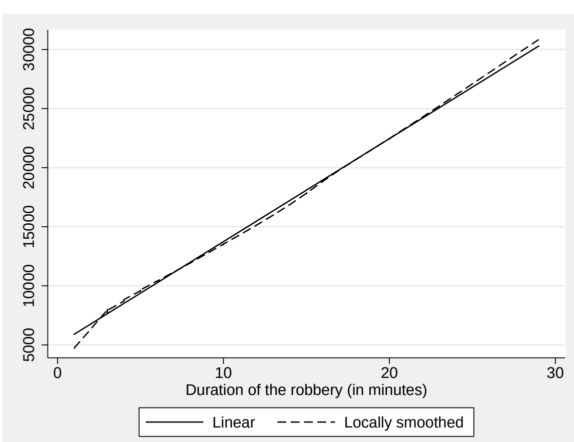
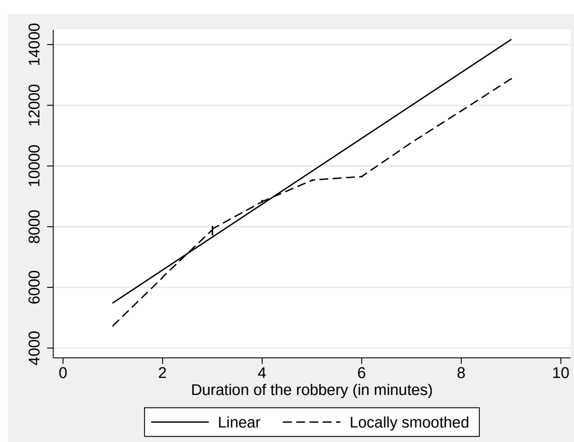
Figure 1: Time series of Italian Robberies and of the Number of Casualties

Figure 2: The Average Haul per Minute





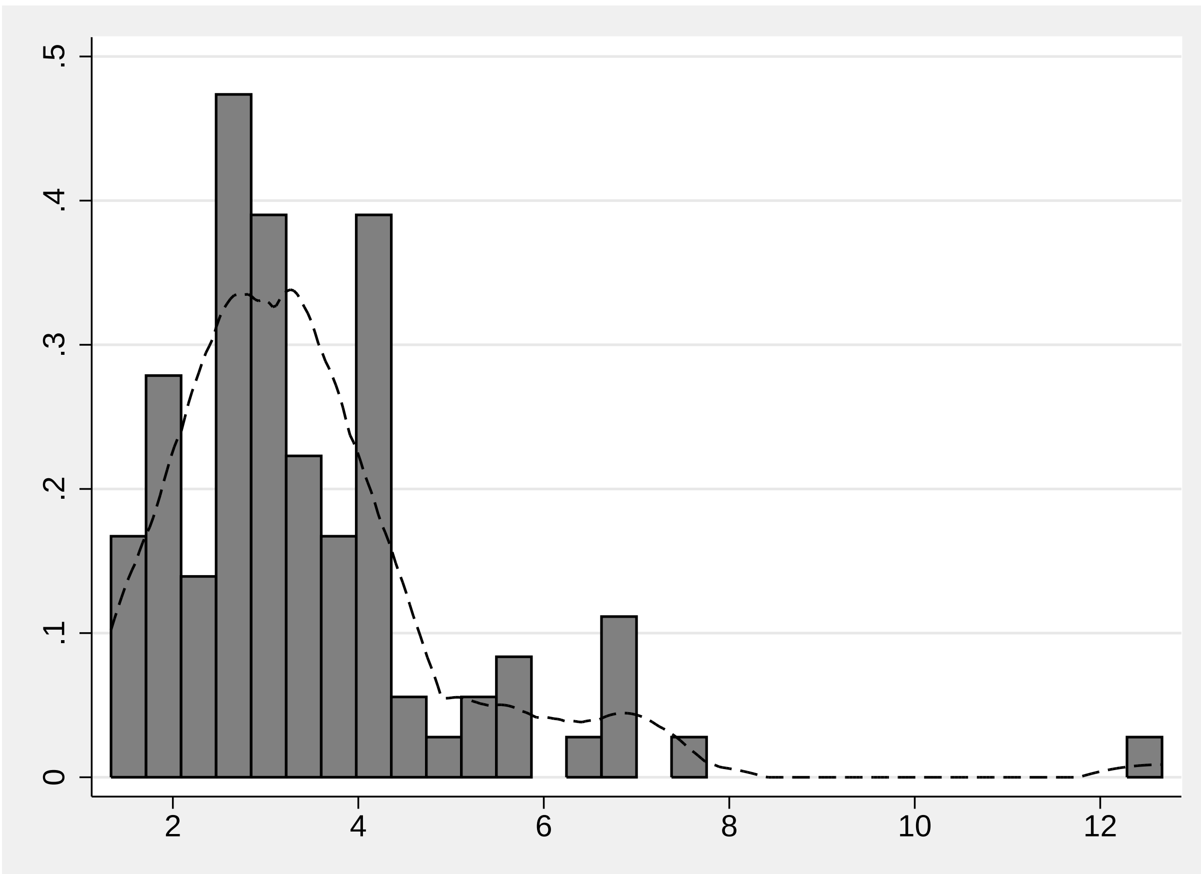


Figure 3: Density of the Sentence Duration (in Years)

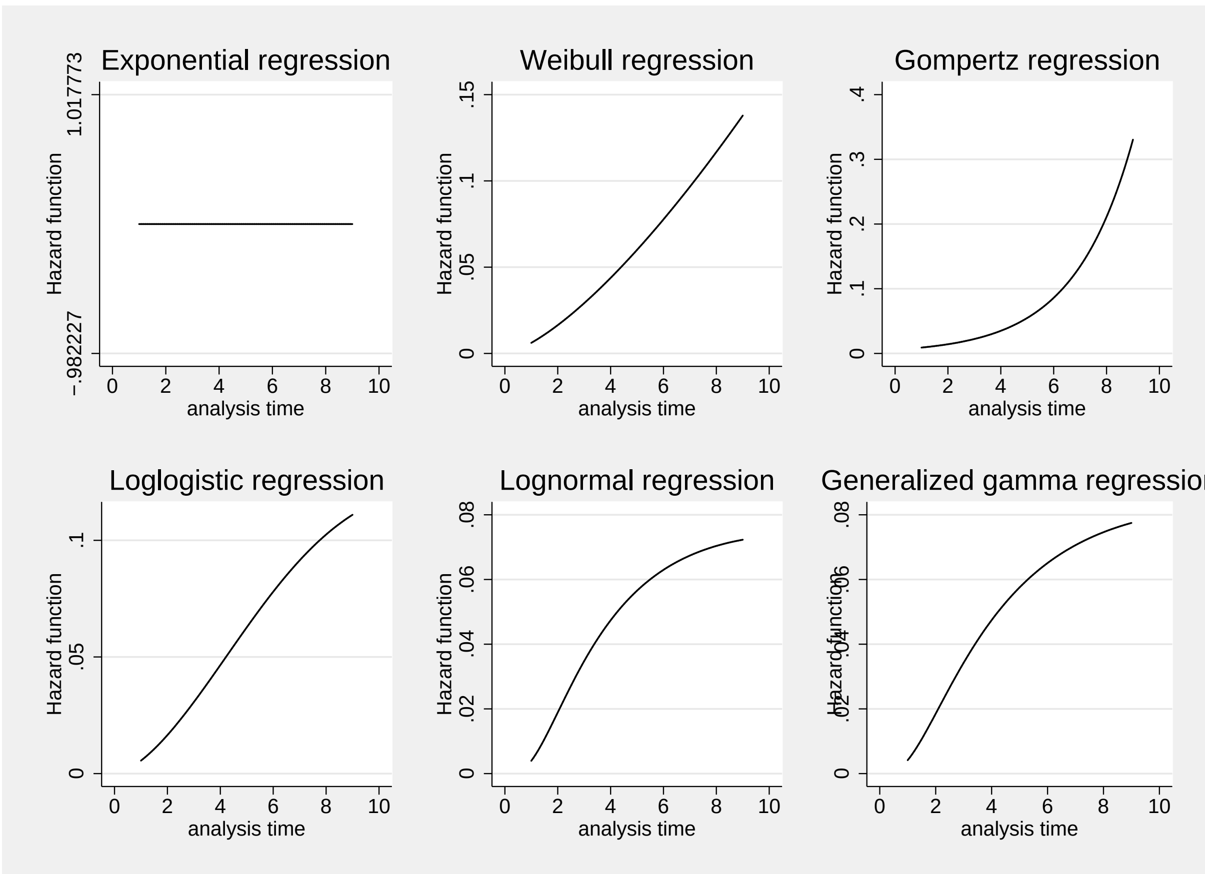


Figure 4: The Estimated Hazard Rate

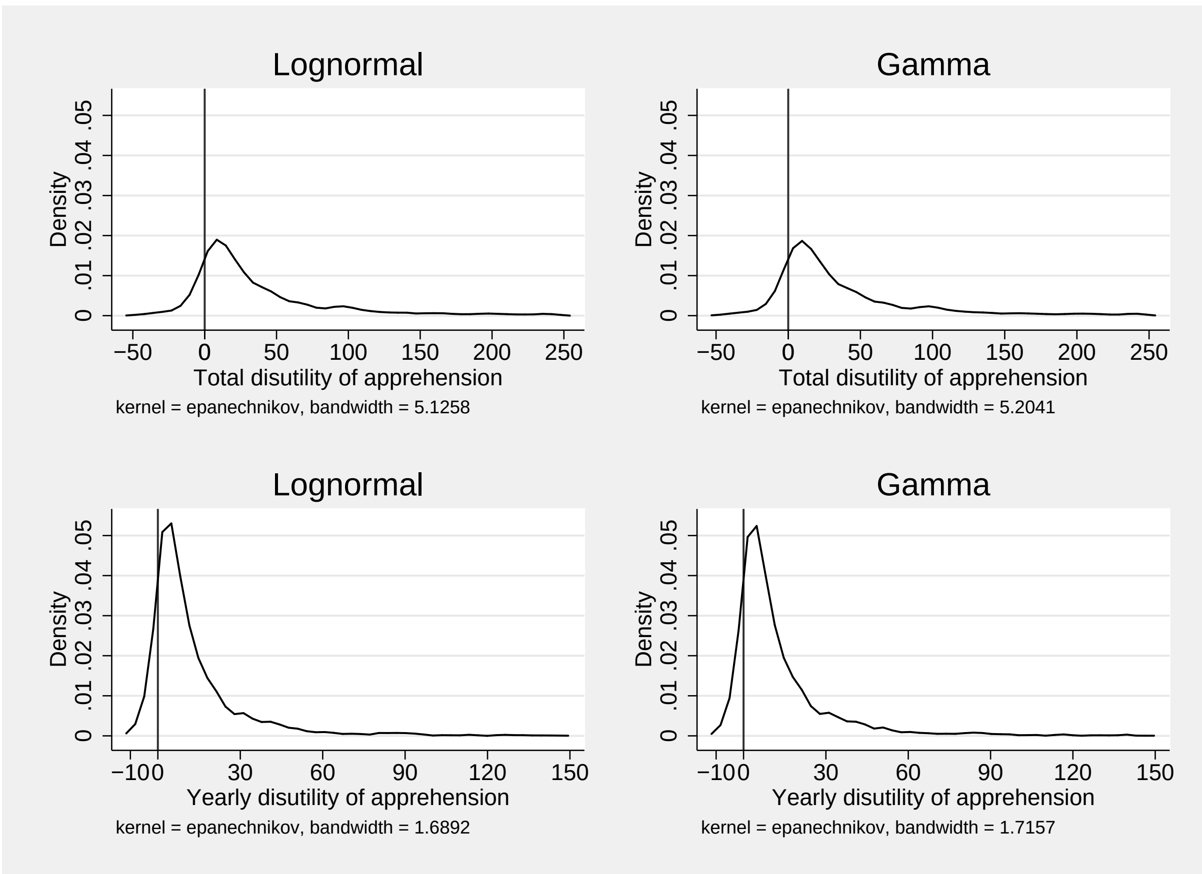


Figure 5: The Distribution of the Conditional Value of Freedom

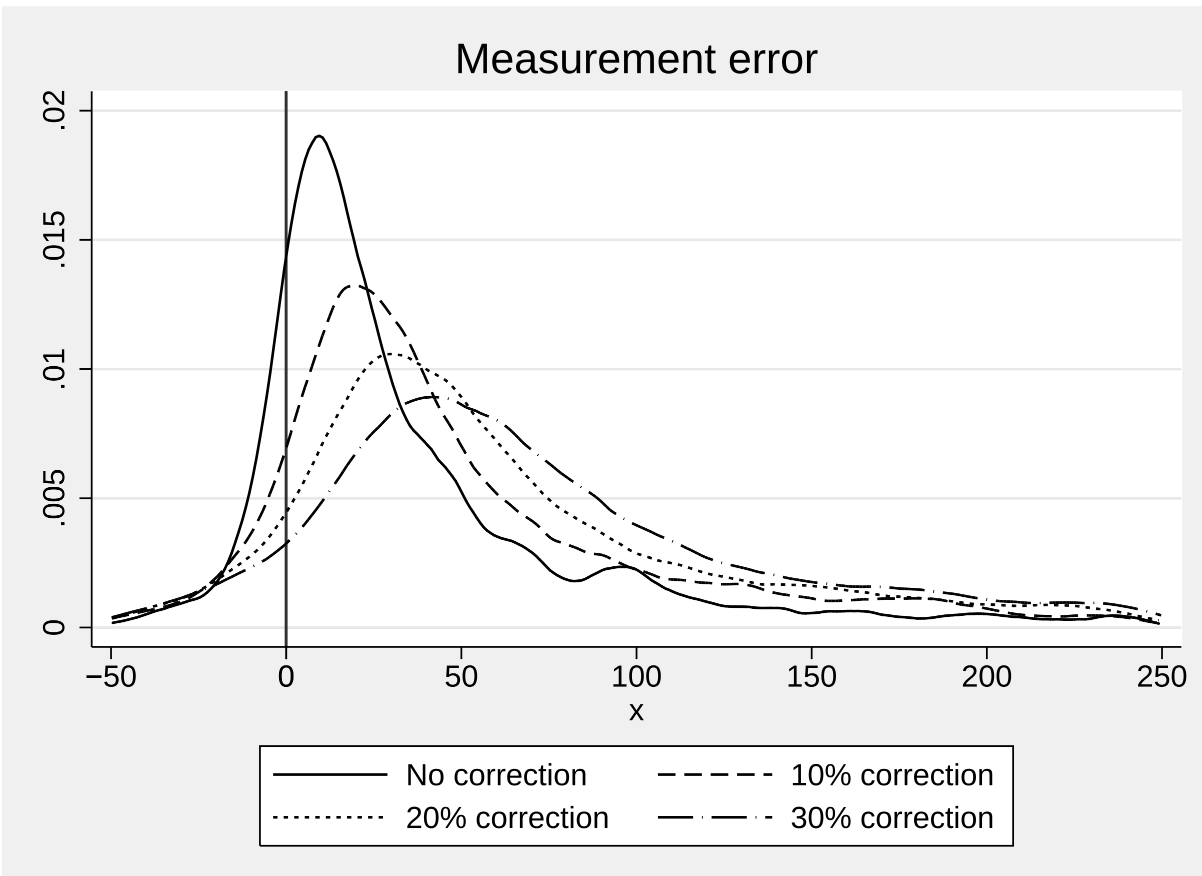


Figure 6: The Distribution of the Conditional Value of Freedom Depending on the Measurement Error

Table 1: Duration of bank robberies

Time	Beg. Total	Arrested	Successful	Survivor Function	Std. Error
1	6136	27	380	0.9956	0.0008
2	5729	78	1298	0.982	0.0017
3	4353	116	1947	0.9559	0.0029
4	2290	35	586	0.9413	0.0038
5	1669	60	833	0.9074	0.0056
6	776	4	84	0.9027	0.0061
7	688	5	57	0.8962	0.0067
8	626	1	61	0.8948	0.0068
9	564	0	13	0.8948	0.0068
10	551	29	214	0.8477	0.0107
11	308	0	6	0.8477	0.0107
12	302	0	11	0.8477	0.0107
13	291	2	14	0.8418	0.0114
14	275	0	3	0.8418	0.0114
15	272	10	64	0.8109	0.0146
16	198	1	4	0.8068	0.0151
17	193	1	2	0.8026	0.0156
18	190	5	0	0.7815	0.0178
19	185	0	4	0.7815	0.0178
20	181	9	63	0.7426	0.0211
22	109	0	2	0.7426	0.0211
23	107	0	3	0.7426	0.0211
25	104	0	37	0.7426	0.0211
27	67	0	1	0.7426	0.0211
28	66	0	1	0.7426	0.0211
29	65	0	1	0.7426	0.0211
30	64	4	60	0.6962	0.0299

Table 2: Summary statistics

Variable	Mean	Std. Dev.	N
Arrested	0.058	0.234	5586
Duration of the robbery (in minutes)	3.2	1.389	5586
Total haul	13854.017	24376.003	5586
Haul	7872.885	11900.172	5586
Firearms	0.136	0.343	5374
Two robbers	0.527	0.499	5586
Three or more robbers	0.139	0.346	5586
Masked robbers	0.427	0.495	5120
Center Italy	0.218	0.413	5586
South Italy	0.291	0.454	5586
Isolated branch	0.254	0.435	5212
Bank with little cash	0.647	0.478	5212
Bank with less than 5 employees	0.498	0.5	5212
Number of Security Devices	5.616	1.184	5586
Average Number of Characteristics per Security Device	1.258	0.379	5578
% of invisible devices	0.675	0.159	5586
Guarded	0.081	0.272	5586

Table 3: Linear Regressions of the Per-Capita Haul

	(1)	(2)	(3)	(4)	(5)	(6)
				Haul		
Duration of the robbery (in minutes)	1,073.88***	1,047.71***	780.55***	1,076.88***	5,231.72***	3,144.16***
	(164.00)	(177.18)	(296.44)	(186.75)	(1,623.57)	(844.83)
Firearms		4,398.84***	-620.16	4,021.45***	-1,593.53	-2,049.87
		(797.15)	(1,675.05)	(835.85)	(1,833.91)	(1,752.52)
Two robbers		-2,085.56***	-1,586.40	-2,595.30***	-2,127.17*	-2,607.55***
		(374.27)	(1,146.81)	(373.16)	(1,115.56)	(370.07)
Three or more robbers		-2,653.65***	-1,584.06	-3,007.34***	-197.08	-3,022.54***
		(613.24)	(1,514.43)	(676.75)	(1,705.74)	(664.21)
Masked robbers		1,723.97***	346.63	1,362.43***	395.61	1,301.93***
		(358.29)	(1,170.64)	(365.36)	(1,072.45)	(368.61)
Center Italy				1,600.26***	1,436.98	1,519.66***
				(398.46)	(1,603.83)	(398.25)
South Italy				1,650.71***	459.51	1,644.98***
				(478.68)	(1,115.93)	(474.10)
Isolated branch				-379.34	-737.19	-415.60
				(353.67)	(1,512.19)	(353.01)
Bank with little cash				-1,334.83***	1,352.32	1,458.19
				(425.81)	(1,282.04)	(1,356.84)
Bank with less than 5 employees				-368.68	266.59	-381.47
				(382.65)	(1,097.37)	(380.83)
Number of Security Devices				-248.72**	288.60	-285.14**
				(123.36)	(395.90)	(123.91)
Average Number of Characteristics				-2,493.54***	2,246.07**	1,606.60
per Security Device				(386.24)	(1,001.13)	(1,047.02)
% of invisible devices				-1,954.36**	2,498.03	-2,232.48**
				(957.67)	(2,718.31)	(969.29)
Guarded				-345.45	-7,069.84*	-557.97
				(800.87)	(3,825.18)	(796.19)
Interaction	Duration ×					
Firearms			1,473.63**		1,633.29**	1,798.59***
			(611.51)		(711.49)	(669.34)
Two robbers			-171.94		-140.35	
			(406.63)		(396.59)	
Three or more robbers			-334.08		-855.85	
			(533.03)		(603.88)	
Masked robbers			409.60		264.77	
			(407.86)		(373.23)	
Center Italy					25.79	
					(508.33)	
South Italy					336.39	
					(412.49)	
Isolated branch					88.81	
					(514.22)	
Bank with little cash					-850.41*	-881.88*
					(466.44)	(477.66)
Bank with less than 5 employees					-189.01	
					(390.55)	
Number of Security Devices					-172.71	
					(132.92)	
Average Number of Characteristics					-1,562.46***	-1,369.87***
per Security Device					(358.76)	(356.20)
% of invisible devices					-1,430.97	
					(909.33)	
Guarded					2,030.87	
					(1,368.14)	
Observations	5586	4908	4908	4549	4549	4549
R-squared	0.016	0.042	0.047	0.058	0.077	0.070

Table 4: Hazard Model Selection Criteria

	Exponential	Weibull	Gompertz	Loglogistic	Lognormal	Gamma
log-L.	-1085.0268	-955.50544	-992.18228	-951.5691	-948.21826	-948.11423
df	14	15	15	15	15	16
AIC	2198.0536	1941.0109	2014.3646	1933.1382	1926.4365	1928.2285
BIC	2287.9709	2037.3508	2110.7045	2029.4781	2022.7765	2030.9911

Table 5: Cox Proportional Hazard Model

	(1)	(2)	(3)
	Cox	Cox	Cox
Firearms	-0.30	-0.28	-0.44**
	(0.19)	(0.19)	(0.21)
Two robbers	-0.55***	-0.53***	-0.54***
	(0.12)	(0.13)	(0.13)
Three or more robbers	-0.46***	-0.47***	-0.60***
	(0.18)	(0.18)	(0.19)
Masked robbers	-0.65***	-0.64***	-0.64***
	(0.13)	(0.13)	(0.13)
Center Italy		-0.16	-0.19
		(0.17)	(0.17)
South Italy		0.07	0.02
		(0.13)	(0.14)
Isolated branch			-0.04
			(0.15)
Bank with little cash			-0.03
			(0.13)
Bank with less than 5 employees			-0.40***
			(0.12)
Number of Security Devices			-0.11**
			(0.05)
Average Number of Characteristics per Security Device			0.02
			(0.16)
% of invisible devices			-0.10
			(0.36)
Guarded			0.19
			(0.23)
Observations	4908	4908	4549

Table 6: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
	Individual-level information				
Age	35.316	10.78	0	65	95
Foreigner	0.082	0.277	0	1	97
Southern	0.351	0.48	0	1	97
Number of robberies	3.351	3.354	1	15	97
Recidivist	0.67	0.473	0	1	97
Plea bargain	0.34	0.476	0	1	97
Total sentence	3.458	1.639	1.333	12.667	95
	Robbery-level information				
Firearms	0.225	0.418	0	1	325
Masked	0.572	0.496	0	1	325
Group robbery	0.689	0.464	0	1	325
Hostages	0.04	0.196	0	1	325
Total haul	12.374	21.608	0	145	325
Year	2004.929	1.501	1993	2009	324

Table 7: Determinants of the Sentence Length

	(1)	(2)	(3)	(4)
	log-Sentence			
Firearms	0.50***	0.36**	0.39***	0.28***
	(0.09)	(0.16)	(0.10)	(0.09)
Masked	0.10	0.08	0.07	0.03
	(0.09)	(0.08)	(0.08)	(0.08)
Group robbery	0.25***	0.14	0.20**	0.09
	(0.09)	(0.11)	(0.08)	(0.08)
Number of robberies		0.02		0.03**
		(0.01)		(0.02)
Recidivist		-0.03		-0.03
		(0.11)		(0.08)
Hostages		0.05		-0.10
		(0.10)		(0.18)
Total haul		0.00*		0.00
		(0.00)		(0.00)
Plea bargain		-0.21*		-0.27***
		(0.12)		(0.08)
Year	-0.00	-0.01		-0.02
	(0.03)	(0.02)		(0.02)
Observations	316	316	95	94
R-squared	0.331	0.431	0.197	0.361

Table 8: Conditional Heterogeneity in D

	% Negative	Mean	St. Dev.	C. Var.	P10	P25	P50	P75	P90
				Total disutility					
Lognormal	0.106	60.39	257.57	4.26	-3.77	6.36	20.47	51.24	118.12
Gamma	0.107	57.92	217.76	3.76	-3.85	6.23	20.57	52.06	119.68
				Yearly disutility					
Lognormal	0.106	16.53	57.60	3.48	-1.36	2.24	6.98	16.03	33.93
Gamma	0.107	15.94	49.19	3.09	-1.37	2.20	7.08	16.35	34.47
N			4054						

Table 9: log-Value of Freedom changes

	Average	SD	P5	P95
Duration of the bank robbery	-0.25	0.03	-0.30	-0.20
Firearms	1.96	0.50	1.13	2.77
Two robbers	1.05	0.19	0.73	1.37
Three or more robbers	1.16	0.26	0.73	1.59
Masked robbers	0.93	0.20	0.65	1.29
Center Italy	0.28	0.25	-0.16	0.66
South Italy	-0.12	0.22	-0.53	0.21
Isolated branch	0.08	0.25	-0.27	0.56
Bank with little cash	-1.21	0.53	-1.91	-0.22
Bank with less than 5 employees	0.59	0.17	0.30	0.87
Number of Security Devices	0.26	0.12	0.06	0.45
Average Number of Characteristics per Security Device	-1.10	0.19	-1.46	-0.80
% of invisible devices	0.10	0.56	-0.78	0.99
Guarded	-0.38	0.39	-1.00	0.21

Table 10: Measurement Error in Duration and D

	% Negative	Mean	St. Dev.	C. Var.	P10	P25	P50	P75	P90
No correction	0.106	60.39	257.57	4.26	-3.77	6.36	20.47	51.24	118.12
10% correction	0.083	96.76	363.13	3.75	-1.61	15.15	37.08	87.01	198.29
20% correction	0.076	133.13	470.19	3.53	0.06	23.49	53.27	118.50	290.82
30% correction	0.073	169.50	577.93	3.41	1.72	31.99	69.31	152.68	385.18

Table 11: log-Change in D that Corresponds to $t^* = 0$

	Mean	St. Dev.	P5	P25	P50	P75	P95
No correction	0.53	0.65	0.03	0.13	0.32	0.66	1.81
10% correction	0.39	0.47	0.02	0.11	0.25	0.49	1.24
20% correction	0.33	0.42	0.02	0.10	0.21	0.41	1.02
30% correction	0.30	0.37	0.02	0.09	0.19	0.36	0.91