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Resistance is Futile: An Essay in Crime and Commitment

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Resistance is Futile: An Essay in Crime and Commitment*

M. Martin Boyer†

Résumé / Abstract.

Ce document de travail étudie un problème de principal-agent dans un contexte que nous appelons de *crime contractuel.* Supposons qu'un agent et un principal s'entendent sur un contrat qui stipule un transfert de fonds d'un joueur (disons l'agent) vers l'autre en fonction de l'état de la nature révélée par le premier joueur. Dans une économie où il existe deux types d'agents, les Véridiques (qui disent toujours la vérité quant à l'état de la nature) et les Changeants (qui annoncent stratégiquement le vrai état ou non), nous montrons qu'il n'existe pas de contrat séparateur. Le contrat de pooling peut ainsi être découpé en deux parties. Si la proportion de Changeants (ξ) dans l'économie est inférieure à un ξ^* donné, alors l'utilité espérée des agents diminue avec une augmentation de la proportion de Changeants. Pour une proportion de Changeants supérieure à ξ^*,l'utilité espérée des agents est indépendante de la proportion exacte de Changeants dans l'économie. Dans les deux cas, la pénalité infligée aux Changeants pris en flagrant délit n'a aucun impact sur la forme du contrat optimal. Investir en prévention est toujours bénéfique si $\xi<\xi^*$. Cet investissement peut par ailleurs être complètement inutile quand $\xi>\xi^*$, dépendant de la proportion initiale de Changeants et de la technologie de prévention, puisque la criminalité y est indépendante de la proportion de Changeants. Enfin, en permettant aux agents de choisir leur type nous trouvons l'équilibre de long terme d'éléments criminels dans l'économie.

This paper studies a principal-agent relationship in a contractual crime setting. Suppose an agent and a principal sign a contract stipulating some transfer of funds from one player (say the agent) to the next (the principal) contingent on the state of the world announced by the first player. In an economy where there are two types of agents, the Truths (who always report the true state of the world) and the Dares (who dare misreport the true state of the world), we show that no separating contract exists. The optimal pooling contract can then be divided into two parts. For a proportion of Dares (x) smaller than some x^*, the agents' expected utility decreases as the proportion of Dares (x) increases. For a proportion greater than x^*, the agents' expected utility is independent of the exact proportion of Dares. In both cases the punishment inflicted to Dares convicted of a crime has no impact on the optimal contract. Investment in prevention is always beneficial if $x<x^*$. On the other hand, because the level of crime is independent of the exact proportion of Dares when $x>x^*$, investment in prevention may have no impact whatsoever on crime, depending on prevention technology and the initial proportion of Dares. Finally, allowing agents to choose their type before the game starts allows us to find the long-run equilibrium proportion of Dares in the economy.

Mots clés : Criminalité et prévention, Absence d'engagement, Aléa moral, Anti-sélection

Keywords : *Crime and Crime prevention, Non-commitment, Moral hazard, Adverse selection*

JEL : G22, C72, D82, D11

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1 Introduction

Crime, crime prevention and crime punishment have always represented a major concern of any society. This is even more true in the United States where two percent of the male workforce is incarcerated (Freeman, 1996). When we add to these numbers the men who are on probation and on parole, almost seven percent of the male workforce is under the supervision of the American penal system. Freeman (1996) compares these numbers to the long-term unemployment rates in Western European countries. These staggering numbers have induced federal and state governments to act to contain this plague.

The recent debate in the popular and scientific press regarding the impact of handguns on crime illustrates society's on-going concern for law enforcement.[1] Proponents of legalizing concealed hand guns argue that crime has been reduced in cities and counties where concealed weapons are legal. Opponents argue that this is not the case because victims of random violence are a minority compared to those who were victimized by someone they knew. Another on-going debate in society is whether an increase in the number of police officers increases or decreases the amount of crime. The observed paradox is that more officers leads to more crime. This is allegedly due to a crime-reporting bias. With few police officers, it is less likely that a crime will be reported, let alone investigated since police activities remain to this day labor intensive. With more officers, the number of crimes may not increase, but the number of reported crimes certainly will

Similar arguments apply to the wave of prison building in the United States. Prison over-crowding has led to new facilities being built. Judges and juries have responded to these new prisons by stiffening prison sentences (such as three-strikes-and-you-are-out provisions). Harsher sentences have kept criminals behind bars for a longer period of time. This has not necessarily reduced the amount of crime in society, however, since longer prison sentences leads to prison overcrowding, which leads to overcrowding litigation and more crime (Levitt, 1995).[2]. Even gun buyback programs are under attack as Mullin (2001) shows that they may actually increase gun ownership since buybacks reduces the cost of owning a firearm. A similar argument was used by Andreoni (1991) for tax amnesty programs.

This paper relates to this debate by looking at the impact of crime punishment and of crime

[1] For the recent debate in scientific journals, see Lott and Mustard (1996,1997), Bartley and Cohen (1998), Black and Nagin (1998), Dezhbakhsh and Rubin (1998) and Bartley (1999).

[2] The same arguments are debated when one considers the death penalty. Opponents and proponents of the death penalty argue on whether it reduces crime, and whether it is more or less costly than a life sentence.

prevention. Although DiIulio (1996) attributes the lingering of the crime-and-punishment debate to a lack of reliable data, we present a theoretical approach in which stiffer (of more lenient) penalties and increased prevention may have no impact on crime.

It has been suggested (see Becker, 1968, and Black and Lind, 1975) that the government (or the principal) should set the penalty for committing a crime to be very large, so that the probability of anyone committing one would be very small. This lottery approach to crime prevention and punishment is not observed in reality. The question is why.[3]

Friedman (1999) criticizes Becker's philosopher-king approach to crime by arguing that Beckerian models generally forget the enforcers' incentives to investigate and punish crimes. For example, if the enforcer is somehow compensated based on the number of convictions, then he may want to prosecute people who did not commit any crime. This will lead to an increase in the number of judicial errors and possibly entrapment.

Similarly, if penalties are too stiff, enforcers may prosecute to reach side agreements with the prosecuted party. Friedman (1995) presents the example of medieval England where enforcers prosecuted defendants only to receive a bribe to drop the charges. We observe the same situation in modern day civil trial litigations when defendants agree to settle out-of-court with no admission of guilt. The conclusion one draws from Friedman (1999) is that rules of law that may appear sub-optimal from a philosopher-king approach may in fact be optimal when we take into account incentive for agents to enforce these laws.

Our paper does not address the case of physical harm. Nevertheless, arguments used in the crime-and-punishment debate also applies to so-called white-collar crimes. Indeed, large penalties on defendants may induce more prosecution only to reach out-of-court settlements (bribes) even though the accused party is not guilty. Also, following Friedman's argument on conviction-based compensation, the habit of plaintiff lawyers in civil courts to collect a percentage of the settlement may increase judicial errors and wrongful convictions.

The philosopher-king approach is based on the premise that the principal chooses an infinite penalty and commits to a pre-specified investigation policy.[4] Both these assumptions may be

[3]See also Becker and Stigler (1974) and Erlich (1973). DiIulio (1996) and Freeman (1996) present an overview of the general debate surrounding crime punishment and law enforcement.

[4]This approach to crime prevention has made it way to popular television. We even find an hyperbole of the infinite penalty argument for menial crime in one episode of *Star Trek: The Next Generation.* In *Justine*, the Marquis of Sade presents a critique of capital punishment for menial crimes. The Marquis's argument is basically that given that a one has stolen a loaf of bread (menial crime), there is no reason for this criminal to spare the life of any witness

questioned in reality.

First of all, penalties are rarely set to infinity, especially for so-called white-collar crimes.[5] Moreover, penalties are determined by the courts. It then does not seem appropriate to assume that the penalty is decided by the principal. Moreover, following the Friedman (1999) approach, infinite penalties may not be optimal because it induces enforcers to prosecute defendants only to extract money from them. Secondly, as argued by Besanko and Spulber (1989), it may not be reasonable to assume that the principal can commit perfectly to verify the agent's action at a cost. The classic argument against commitment is simple. Given the agent believes the principal can commit, he will always tell the truth. The principal then never has an incentive to investigate since it is costly and always reveals that the agent has told the truth. Put another way, after the agent has announced his type, both players have an incentive to renegotiate their agreement. It is mainly with respect to *commitment* that the present paper differs from the previous literature. We assume that the principal cannot bind herself to some investigating strategy based on the players' actions.

A consequence of the principal's inability to commit is that the agent's optimal strategy may be to commit a crime. The models developed by Sanchez and Sobel (1993), Graetz, Reinganum and Wilde (1986), Picard (1996), Khalil (1997) and Boyer (2000) reach similar conclusions. In these papers there are agents who successfully cheat and who extract a rent from the principal on some occasions. The inability to commit is not the same as the governement's time inconsistency in its policy (see Boadway, Marceau and Marchand, 1996). The problems related to the sequential enforcement process is also studied in Shavel (1991) and Jost (1997).

We construct a game theoretic model between an agent and a principal where agents have a monetary incentive to commit a crime. The agent's possible actions are *commit a crime* and *be honest*, while the principal's possible actions are *investigate the agent* and *not investigate*. By committing a crime the agent may or may not be caught. If the agent is caught by the principal, he will pay a penalty.

We implicitly include in the model an agent's propensity to commit crime. Graetz, Reinganum and Wilde (1986) view this propensity difference in an income tax context as having some agents who are strategic compliers (may under-report income), while others who are habitual compliers

(venial crime) since all crimes are punishable by death. The marginal (at least on the material plane) penalty for killing all the witnesses is therefore nil. There is therefore no reason to spare the life of any potential witness if all crime is punishable by death. Not surprisingly, the Marquis leaves to theologians the burden of arguing whether or not the two commandments *Thy Shalt Not Kill* and *Thy Shalt Not Steal* are equivalent from the spiritual standpoint.

[5] In a hierarchy, Saha and Poole (2000) present a case where infinite penalties are not optimal.

(never under-report income). Picard (1996) presents a similar model in an insurance context. In our paper, we make use of these different propensities of agents to engage in a strategic game with the principal. Agents who never play the game (propensity is zero) are called Truths; whereas agents who dare play the crime-game are called Dares. Prevention is modeled in this paper as device that turns Dares into Truths.

We use an unemployment insurance framework to study crime. The possible crime is then for an agent to request unemployment insurance benefits when working. We can also apply the model to many other insurance framework: automobile insurance, social security, health insurance. Income tax fraud also fits in this kind of model. The model may also be viewed as one where a manager reports positively false accounting figures to the board to increase his year-end bonus, or negatively false accounting figures to reduce his options' strike price. Another application may be a defense contractor who artificially inflates his cost of production to collect more money from government. A final application comes from the pollution abatement literature. The polluter may know how much hazardous waste he is releasing in the atmosphere. The government does not know how much has been released, and must incur a verification cost to make sure firms have not polluted more than their limit.[6]

The results of the paper are the following. First, there does not exists a contract that separates the Truths from the Dares when the principal cannot commit to an investigating strategy. The pooling contract is such that, when the proportion of Dares (given by ξ) is smaller than some ξ^*, the agents' expected utility decreases as the proportion of Dares increases . For a proportion of Dares greater than ξ^*, the agents' expected utility is independent of the exact proportion of Dares, since the pooling contract is independent of the exact proportion of Dares when $\xi > \xi^*$. In this case, investment in crime prevention may have no impact on the amount of crime.

The paper is constructed as follows. In the next section, we present the setup of the game between the agents and the principal. In Section 3 we present the benchmark case where each agent's type is common knowledge. We let each agent's type be private information in Section 4. The optimal contract, as a function of the proportion of criminal elements in the economy, is derived and discussed. We end Section 4 by introducing crime prevention in the model. Section 5 concludes and leaves room for further research.

[6] We do not want to explain in this paper the case of physical crime (such as murder and rape). Our paper focuses exclusively on non-violent contractual crimes.

2 Assumptions and Setup

Using an unemployment insurance framework, we have agents who are risk averse and a principal who is risk neutral. Agents may be of two types: Truths or Dares. Truths always tell the truth. Dares commit a crime if they believe it is in their own best interest. The proportion of Dares in the economy is given by ξ. All agents, Truths and Dares alike, have the same VonNeumann-Morgenstern utility function over final wealth (with $U'(.) > 0$, $U''(.) < 0$ and $U'(0) = \infty$), and the same initial wealth, Y. An agent may be employed or unemployed. If employed an agent receives labor income W, otherwise he has no income. An agent is unemployed with probability $\pi < \frac{1}{2}$. Whether the agent is employed or not is unknown to the principal. The principal may, however, investigate the agent at cost c to acquire this information. If caught committing a crime the agent must incur some penalty. The sunk cost penalty is represented as some disutility k which is fixed,[7] such as prison time. We could let the principal collect a small fraction of the penalty as in Picard (1996) without altering our results significantly.[8]

The possible actions for the agent are to request unemployment insurance benefits or not. The possible actions for the principal are to investigate the agent or not. We assume that unemployment insurance works for the agents' greater good in the sense that the premium (p) is exactly equal to the expected benefits paid in case of unemployment plus expenses due to crime. Expenses due to crime include payments made to agents who were not caught committing a crime, and the budget devoted to the investigation of agents. The sequence of play is

In the first stage of the game the agents are offered a menu of contracts that specify an unemployment insurance benefit β and a premium p. In the second stage of the game, Nature decides whether each agent is employed or not. This information is private to each agent. In stage three, the agent must decide whether to request benefits. The last move belongs to the principal who must decide whether to investigate an agent. Finally the payoffs are paid and the game ends.

[7] The implications of the model are the same whether the penalty k is denominated in utility terms or in monetary terms as long as the penalty is sunk.

[8] The only difference in the setup is that the premium would reflect the fact that part of the penalty is paid back to the principal when an investigation reveals that an agent has committed a crime. This would reduce the premium paid by the agent. Adding such a penalty would only complicate unduly the model since none of the main results would be altered. For that reason, we use the most simple penalty: The sunk cost penalty.

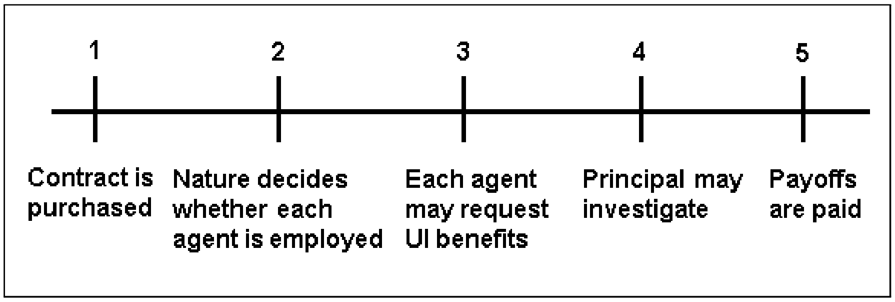

Figure 1: Sequence of play.

3 Type Known

3.1 Truths

If each agent's type is known, then the principal can design a contract that targets each type of agent. It is then clear that the Truths will choose to be fully insured. Furthermore, their contract will be independent of the penalty k. We present this as our first proposition.

Proposition 1 *Under full information on the type, the optimal contract designed for the Truths is independent of the penalty.*

Proof: The maximization problem for the Truth is

$$\max_{p,\beta} EU = \pi U(Y - p + \beta) + (1-\pi) U(Y + W - p) \tag{1}$$

subject to $p = \pi\beta$. Obviously, the penalty is never a parameter to consider in this maximization problem.•

The intuition behind this result is straightforward. Since the Truths always tell the truth, they can never be caught committing a crime. Therefore they never incur the penalty.

3.2 Dares

The Dares' problem is more complicated. The principal must design a contract which specifies a combination of coverage and price that maximizes the Dares' expected utility subject to equilibrium strategy constraints. The payoffs to the Dares and the principal contingent on all possible actions are displayed in table 1.

Table 1

Payoffs to the Dare and the principal contingent on their actions and the state of the world.

State of the world	Action of Dare	Action of Principal	Payoff to Dare	Payoff to Principal
Employed	*Don't request benefits*	*Investigate*	$U(Y+W-p)$	$p-c$
Employed	Don't request benefits	Don't investigate	$U(Y+W-p)$	p
Employed	Request benefits	Investigate	$U(Y+W-p)-k$	$p-c$
Employed	Request benefits	Don't investigate	$U(Y+W-p+\beta)$	$p-\beta$
Unemployed	*Don't request benefits*	*Investigate*	$U(Y-p+\beta)$	$p-\beta-c$
Unemployed	*Don't request benefits*	*Don't investigate*	$U(Y-p)$	p
Unemployed	Request benefits	Investigate	$U(Y-p+\beta)$	$p-\beta-c$
Unemployed	Request benefits	Don't investigate	$U(Y-p+\beta)$	$p-\beta$

The contingent states in italics never occur in equilibrium.
They represent actions that are off the equilibrium path.

It is clear from this setup that the equilibrium of the game is in mixed strategies. Moreover, the equilibrium is perfect Bayesian. Let η be the probability that a Dare requests benefits when employed (i.e. the probability a Dare commits a crime), and let ν be the probability of investigating an agent who requests benefits. In equilibrium, η and ν are given by

$$\eta = \left(\frac{\pi}{1-\pi}\right)\left(\frac{c}{\beta-c}\right) \tag{2}$$

$$\nu = \frac{U(Y+W-p+\beta) - U(Y+W-p)}{U(Y+W-p+\beta) - U(Y+W-p) + k} \tag{3}$$

Given those optimal strategies, it is possible to find the price of an unemployment insurance policy that is the fairest to the agents. Given the cost of investigating an agent and the fact that some crime goes undetected, the fair price of this contract is given by

$$p = \pi\beta + (1-\pi)\beta\eta(1-\nu) + c\nu[\pi + (1-\pi)\eta] \tag{4}$$

where $(1-\pi)\beta\eta(1-\nu)$ represents the expected extra amount of money that is extracted by agents who commit a crime, and $c\nu[\pi+(1-\pi)\eta]$ represents the amount of money spent on investigations.

The problem faced by the principal is then

$$\begin{aligned}\max_{p,\beta} EU &= \pi U(Y-p+\beta) + (1-\pi)(1-\eta)U(Y+W-p) \\ &\quad + (1-\pi)\eta[(1-\nu)U(Y+W-p+\beta) + \nu U(Y+W-p) - \nu k]\end{aligned} \tag{5}$$

subject to

$$p = \pi\beta + (1-\pi)\beta\eta(1-\nu) + c\nu[\pi + (1-\pi)\eta] \tag{6}$$

$$\eta = \left(\frac{\pi}{1-\pi}\right)\left(\frac{c}{\beta-c}\right) \tag{7}$$

$$\nu = \frac{U(Y+W-p+\beta) - U(Y+W-p)}{U(Y+W-p+\beta) - U(Y+W-p) + k} \tag{8}$$

$$\text{and a Participation Constraint} \tag{9}$$

We see that the probability a Dare commits a crime (η) is independent of the premium (p). On the other hand, the probability the principal investigates (ν) depends on the benefits and the premium. Therefore, by choosing the optimal (p, β) pair, the principal must rationally anticipate the impact the contract has on the strategic behavior of the players. We see that the parameter k appears in the function to maximize (5) as well as in constraint (8). This means that the penalty for getting caught committing a crime may have an impact on the optimal contract. Our second proposition shows this is not the case, however.

Proposition 2 *Under full information on the type, the optimal contract designed for the Dares is independent of the penalty.*

Proof: Suppose we have an interior solution (the participation constraint does not bind). It is possible to simplify the problem by substituting equations (7) and (8) into (6) and (5). This yields

$$\max_{p,\beta} EU = \pi U(Y-p+\beta) + (1-\pi)U(Y+W-p) \tag{10}$$

$$\text{Subject to } p = \pi\frac{\beta^2}{\beta-c}$$

Again, as in proposition 1, the penalty is irrelevant once we substituted for all the constraints.•

The reasons the penalty is irrelevant in determining the contract are three-fold. The first reason is that the principal is the last player to move. Second, the principal is unable to commit to an investigating strategy. Third, the penalty is a sunk cost.

The first two reasons are explained by the fact that the principal chooses her investigation policy so that Dares are indifferent between committing a crime and telling the truth, given they are employed. Clearly Dares suffer more by getting caught if the penalty is high. Thus for Dares to remain indifferent between committing a crime or not as the penalty increases, the principal must reduce her probability of investigating. The reduction (or increase) in the investigation probability and the increase (or reduction) in the penalty are exactly offset because the principal cannot commit to an investigating strategy, and must therefore only react to the Dares' action.

The sunk cost penalty prevents the principal from gaining anything by investigating; she can only not pay for a claim found to be unjustified. Therefore investigations cannot be used as a rent extracting device. If part of the penalty is paid to the principal, however, then that part of the penalty will have an impact on the optimal contract. Nevertheless, the sunk cost portion would still have no impact.[9]

We are now able to infer what will be the impact of the penalty on the amount of crime in the economy. This yields the following straightforward corollary to proposition 2.

Corollary 1 *The penalty has no impact on the amount of crime in the economy composed only of Dares.*

Proof: From (7) a Dare commits a crime with probability $\eta = f(\beta, \pi, c)$. The impact of k on η is then given by $\frac{\partial \eta}{\partial k} = \frac{\partial f}{\partial \beta}\frac{\partial \beta}{\partial k}$ since π and c are parameters. From proposition 2 we know that β is independent of k. It follows that η is independent of k.•

This corolarry follows directly from the proof of proposition 2. Since the penalty has no impact on the shape of the optimal contract (i.e., β is independent of k), and since the only variable in the problem that has an impact on the Dare's probability of commiting a crime is the indemnity payment β, it follows that the sunk cost penalty has no impact on the amount of crime in the economy. As for the indemnity payment, we know that the optimal contract for the Truths requires $\beta = W$. For the Dares, the optimal contract is presented in the following lemma:

[9] Suppose that on top of the sunk cost penalty k the agent must pay the principal some monetary amount m if caught committing a crime. The payoff table would then change: An agent caught committing a crime would have payoff of $U(Y - p + W - m) - k$, whereas the principal would have payoff of $p - c + m$. Simplifying the overall problem as before, the simplified problem to maximize would then be

$$\max_{p,\beta} EU = \pi U(Y - p + \beta) + (1 - \pi) U(Y + W - p)$$

$$\text{Subject to } p = \pi \frac{\beta(\beta + m)}{\beta + m - c}$$

Again we see that the sunk cost penalty k has no impact whatsoever on the optimal contract.

Lemma 1 *The optimal level of coverage for the Dares solves*

$$\frac{U'\left(Y-\pi\frac{\beta^2}{\beta-c}+\beta\right)}{\pi U'\left(Y-\pi\frac{\beta^2}{\beta-c}+\beta\right)+(1-\pi)U'\left(Y+W-\pi\frac{\beta^2}{\beta-c}\right)}=\frac{\beta(\beta-2c)}{(\beta-c)^2} \tag{11}$$

Proof: After substituting for the constrained value of p, the first order condition of (10) is

$$\begin{aligned}\frac{\partial EU}{\partial\beta} &= 0=\pi U'\left(Y-\pi\frac{\beta^2}{\beta-c}+\beta\right)\left[1-\pi\frac{\beta(\beta-2c)}{(\beta-c)^2}\right] \\ &\quad -(1-\pi)U'\left(Y+W-\pi\frac{\beta^2}{\beta-c}\right)\pi\frac{\beta(\beta-2c)}{(\beta-c)^2}\end{aligned} \tag{12}$$

Rearranging the terms completes the proof.•

It is interesting to note that the denominator on the left hand side of (11) represents the expected marginal utility of the Dares who buy this contract. The next logical question that comes to mind is what would happen if an agent's type is known only to himself. In particular, does a separating contract that identifies each type of agent exist?

4 Type Unknown

4.1 Contract

The classical approach to the problem is for the principal to design a contract that maximizes the utility of one type of agent subject to participation and self-selection constraints. Without loss of generality let the principal maximize the expected utility of the Truths.[10] Denoting by a subscript T the allocation of the Truths, and by D, the allocation of the Dares, the optimal separating contract maximizes the following problem:

$$\max_{\beta_T,p_T,\beta_D,p_D,\eta,\nu} EU_T=\pi U\left(Y-p_T+\beta_T\right)+(1-\pi)U\left(Y+W-p_T\right) \tag{13}$$

subject to

$$\begin{aligned}&\pi U\left(Y-p_D+\beta_D\right)+(1-\pi)(1-\eta)U\left(Y+W-p_D\right)\\ &\quad+(1-\pi)\eta(1-\nu)U\left(Y+W-p_D+\beta_D\right)\\ &\quad+(1-\pi)\eta\nu\left[U\left(Y+W-p_D\right)-k\right]\end{aligned} \geq \pi U(Y)+(1-\pi)U\left(Y+W\right) \tag{14}$$

$$\pi U\left(Y-p_T+\beta_T\right)+(1-\pi)U\left(Y+W-p_T\right)\geq\pi U\left(Y\right)+(1-\pi)U(Y+W) \tag{15}$$

[10] It is typical to assume that the principal assigns no weight to the utility of criminal agents, or to the utility of agents caught committing a crime. This contrasts with the Polinsky and Shavell (1999) normative approach to crime and punishment where social welfare is maximized.

$$\begin{array}{c}\pi U\left(Y-p_D+\beta_D\right)+(1-\pi)(1-\eta)U\left(Y+W-p_D\right)\\ +(1-\pi)\eta(1-\nu)U\left(Y+W-p_D+\beta_D\right)\\ +(1-\pi)\eta\nu\left[U\left(Y+W-p_D\right)-k\right]\end{array} \geq \begin{array}{c}\pi U\left(Y-p_T+\beta_T\right)\\ +(1-\pi)U\left(Y+W-p_T+\beta_T\right)\end{array} \quad (16)$$

$$\pi U\left(Y-p_T+\beta_T\right)+(1-\pi)U\left(Y+W-p_T\right) \geq \pi U\left(Y-p_D+\beta_D\right)+(1-\pi)U\left(Y+W-p_D\right) \quad (17)$$

$$p_T=\pi\beta_T \quad (18)$$

$$p_D=\pi\beta_D+(1-\pi)\beta_D\eta\left(1-\nu\right)+c\nu\left(\pi+(1-\pi)\eta\right) \quad (19)$$

$$\eta,\nu\in[0,1] \quad (20)$$

Equations (14) and (15) are the participation constraints of each type of agent, whereas (16) and (17) represent the incentive compatibility constraints of each type of agent. Equations (18) and (19) are the principal's participation constraints (zero-profit constraints) associated with the Truths' and the Dares' contract respectively. Finally, (20) are the boundary conditions on the probability of committing a crime and of investigating.

The following theorem shows that there cannot be a separating equilibrium in this economy.

Theorem 1 *If there are two types of agents in the economy who differ only with respect to their propensity to commit a crime, and if the principal is bound to offer a break-even contract to each type of agent, then it will not be possible to differentiate those who potentially commit a crime (Dares) from those who never do (Truths). In other words, no separating contract exists.*

Proof: See appendix A. •

We therefore have a pooling contract in this economy, whatever the proportion of Dares is. Three contracts are then possible in this situation, depending on the behavior of the players in the last stages of the game. The three cases are: $\eta<1$ and $\nu>0$; $\eta=1$ and $\nu>0$; $\eta=1$ and $\nu=0$. In other words, in the first case both the agent and the principal end up playing mixed strategies; the agent randomizes between committing a crime and not committing a crime given that he is a Dare who is employed; whereas, given that an agent has requested benefits, the principal sometimes investigates and sometimes does not. In the second case, Dares always request benefits, whether employed or not, whereas the principal still randomizes between investigating an agent who requested benefits or not. In the last case, the Dares always request benefits and the principal never investigates.[11]

[11] The case where the principal never investigates and Dares randomize is not a sustainable Nash equilibrium; Dares always have an incentive to commit a crime all the time if the principal never audits.

It is then possible to derive the optimal contract for the different situations. Let us start with the case where $\eta < 1$ and $\nu > 0$.

Proposition 3 *If $\eta < 1$ and $\nu > 0$, which occurs only if the proportion of Dares is larger than $\overline{\xi} = \frac{\pi}{1-\pi}\left(\frac{c}{\beta_{\eta\nu}-c}\right)$, then the optimal pooling contract is exactly the same as the contract bought by the Dares in an economy where an agent's type is known.*

Proof: See appendix B. •

When $\eta < 1$ and $\nu > 0$, it becomes impossible to infer the proportion of Dares from the type of contract offered. In other words, since the optimal contract is independent of the proportion of Dares when $\xi > \xi^*$, it follows that no information may be gathered from the shape of the contract that is bought.

In the two other cases, we have the following propositions.

Proposition 4 *If $\eta = 1$ and $\nu > 0$, then*

$$\nu_{0\nu}^* = 1 - \frac{\pi}{\xi}\frac{U'\left(Y - p_{0\nu}^* + \beta_{0\nu}^*\right) - U'\left(Y + W - p_{0\nu}^*\right)}{\pi U'\left(Y - p_{0\nu}^* + \beta_{0\nu}^*\right) + (1-\pi)U'\left(Y + W - p_{0\nu}^*\right)} \tag{21}$$

$$p_{0\nu}^* = \left(\frac{\pi^2}{\xi\left(1-\pi\right)} + 2\pi + 1\right)c \tag{22}$$

$$\beta_{0\nu}^* = c\left[1 + \frac{\pi}{\xi\left(1-\pi\right)}\right] \tag{23}$$

Proof: See appendix B. •

Proposition 5 *If $\eta = 1$ and $\nu = 0$, then*

$$p_{00}^* = \pi\beta_{00}^*\left[1 + \xi\left(\frac{1-\pi}{\pi}\right)\right] \tag{24}$$

and β_{00}^* solves

$$\frac{U'\left(Y - p_{00}^* + \beta_{00}^*\right)}{\pi U'\left(Y - p_{00}^* + \beta_{00}^*\right) + \left(1-\pi\right)U'\left(Y + W - p_{00}^*\right)} = 1 + \xi\left(\frac{1-\pi}{\pi}\right) \tag{25}$$

Proof: See appendix B. •

It is interesting to note when $\eta = 1$ and $\nu > 0$ that the optimal contract does not depend on the equilibrium investigating strategy of the principal. We reach that conclusion by noting that both $\beta^*_{0\nu}$ and $p^*_{0\nu}$ are independent of $\nu^*_{0\nu}$. In fact, the only variable that is chosen by the principal is the level of benefits. By choosing $\beta^*_{0\nu}$, we get $p^*_{0\nu}$, and then $\nu^*_{0\nu}$. In the case of $\eta = 1$ and $\nu = 0$, we again have that the only variable that is truly chosen is β^*_{00}, since p^*_{00} is obtained directly from β^*_{00}. Moreover when we look at the function that determines p^*_{00}, we note that it is the very same functional form that one uses to obtain the optimal insurance contract when a proportional loading factor exists. In fact, the β^*_{00} that solves the problem is chosen exactly as if the loading factor is equal to $\xi\frac{1-\pi}{\pi}$. As $\xi \to 0$, we have the first best insurance contract ($\beta^*_{00} = W$).

In the three possible contracts, the only truly endogenous variable is the benefit (β). All other variables that a priori needed to be determined disappear after simplifying all the required equations. Given that we have three contract forms, it becomes imperative to determine which contracts applies when. We show this in the following theorem.

Theorem 2 *The case where $\eta = 1$ and $\nu > 0$ is always dominated by the case where $\eta = 1$ and $\nu = 0$ for all ξ. The case where $\eta = 1$ and $\nu = 0$ dominates the case where $\eta < 1$ and $\nu > 0$ for all $\xi < \xi^*$, and the case where $\eta < 1$ and $\nu > 0$ dominates the case where $\eta = 1$ and $\nu = 0$ for all $\xi > \xi^*$. Furthermore, $\xi^* > \overline{\xi} = \frac{\pi}{1-\pi}\left(\frac{c}{\beta_{\eta\nu}-c}\right)$.*

Proof: See appendix C •

All aspects of this theorem are shown in figures 2A through 2C.[12] We plotted in figures 2A and 2B (in figure 2B we focus on the interesting part of figure 2A) the expected utility received by the Truths in each type of contract. We see that the contract where $\eta = 1$ and $\nu > 0$ is always dominated by the contract where $\eta = 1$ and $\nu = 0$. This result is made clearer in figure 2C where we plotted the difference in utilities from each contract. The only point where these two curves come in contact is when the proportion of Dares is such that the principal's investigation probability is zero ($\nu = 0$). For any other proportion of Dares, the contract where $\eta = 1$ and $\nu = 0$ is preferred.[13]

We also see in figures 2A and 2B that for lower values of ξ the expected utility of Truths is greater when $\eta = 1$ and $\nu = 0$, whereas their expected utility is greater with $\eta < 1$ and $\nu > 0$ for larger values of ξ. The two contracts intersect when $\xi = \xi^*$. $\overline{\xi}$ is then the proportion of Dares such

[12] We used a CRRA utility function of the form $ln(\bullet)$. The value of the parameters used in the example are $Y = 1$, $W = 20$, $\pi = 0.4$, $c = 4$ and $k = 5$. The first best utility is equal to 2.5649. Autarchy yields expected utility 1.8267.

[13] Incidently, we could also show that the case where $\eta = 1$ and $\nu > 0$ is always dominated by the case where $\eta < 1$ and $\nu > 0$ for all $\xi > \overline{\xi} = \frac{\pi}{1-\pi}\left(\frac{c}{\beta_{\eta\nu}-c}\right)$.

that the contract where $\eta = 1$ and $\nu > 0$ and the contract where $\eta < 1$ and $\nu > 0$ are tangent. We note that this tangency point occurs to the left of ξ^*.

In figure 3, we plotted the optimal combination of contracts. This optimal contract is such that the Truths' expected utility is decreasing in ξ, up until the point where $\xi = \xi^*$. At this point, a higher proportion of Dares does not alter the expected utility of the Truths. This pattern is to be expected since when the principal never investigates ($\xi < \xi^*$), the shape of the optimal contract is closely similar to the optimal contract where there is a proportional loading factor on the premium. As the loading factor increases (in our case as ξ increases), the expected utility of agents is reduced because we move away from the first best allocation (where $\xi = 0$). On the second part of the curve ($\xi > \xi^*$), the expected utility of agents is constant because Dares adjust their behavior to the proportion of Dares. As ξ increases (which lowers expected utility), the probability that any one Dare commits a crime is decreased (which increases expected utility). In equilibrium, the two effects cancel out as we showed in proposition 3.

There is a logic behind this combination of contracts. When there are only a few criminal elements in the economy, enforcing the law becomes more costly than letting crime go unpunished. To illustrate this, consider the case where there is only one Dare in a large economy of N individuals. The cost of not investigating any crime is then $(1-\pi)\beta$. On the other hand, given the same benefit and the fact that a Dare always cheats in this situation, enforcing the law (investigating with probability ν) would cost $(1-\pi)(1-\nu)\beta + N\pi\nu c + (1-\pi)\nu c$.[14] Not investigating is then optimal if its cost is smaller than the cost of investigating. This translates into

$$(1-\pi)\beta - (1-\pi)(1-\nu)\beta - N\pi\nu c - (1-\pi)\nu c \leq 0 \tag{26}$$

This inequality holds if and only if $\beta \leq \left(N\frac{\pi}{1-\pi} - 1\right)c$. This obviously holds as N gets large.

As the number and the proportion of Dares increase in the economy, we have that crime investigation becomes profitable. Indeed as the number of agents who potentially commit a crime increases, the cost of investigating becomes lower than the cost of not investigating. To illustrate, suppose there are D Dares in the economy. Investigating with probability ν is then optimal if and only if

$$D(1-\pi)\beta - D(1-\pi)(1-\nu)\beta - N\pi\nu c - D(1-\pi)\nu c \leq 0 \tag{27}$$

[14] Where $(1-\pi)(1-\nu)\beta$ is the expected cost of not auditing the one Dare, and $N\pi\nu c$ is the cost of the investigating at random N agents who are truly unemployed and $(1-\pi)\nu c$ is the expected cost of investigating the one Dare who committed a crime.

In figure 4, we plotted the optimal benefit and the unconditional probability of crime as a function of the proportion of Dares. We note that the optimal benefit decreases as ξ increases, up until $\xi = \xi^*$. At $\xi = \xi^*$ there is a discontinuity; the optimal benefit increases abruptly and then remains constant as the proportion of Dares increases. Note that the optimal benefit on the portion $\xi > \xi^*$ is such that the benefit is greater than the possible wage ($\beta > W$).[15] This is explained by the fact that the principal, by promising to pay greater benefits in case of unemployment, sends a message that she will investigate with greater probability. In other words, the principal designs the contract as to implicitly commit to investigate more often agents who claim to be unemployed. This implicit commitment to investigate is only observed on the segment $\xi > \xi^*$ because for $\xi < \xi^*$, the principal never needs to signal since she never investigates.

In figure 5, we plotted the Dare's probability of committing a crime (η), and the probability the principal investigates (ν). We note the discreet jump in both measures when $\xi = \xi^*$. In the case of crime, the probability any one Dare commits a crime drops from 1.00 to 0.82, and keeps decreasing as the proportion of Dares increases. The principal's investigation probability (given that benefits have been requested) increases from 0.00 to 0.18, where it remains for any proportion of Dares greater than ξ^*.

4.2 Crime Prevention

So far only the optimal contract has been presented. This contract is such that it is impossible to separate the two types of agents and that it is independent of the proportion of Dares as long as it

[15] This is easily shown theoretically by using lemma 1. Without loss of generality, we can concentrate on the case where $\xi = 1$ to find the optimal benefit for any $\xi > \xi^*$ (since the benefit is constant over that part of the distribution). We then have that

$$\frac{\partial EU}{\partial \beta} = \pi U'\left(Y - \pi\frac{\beta^2}{\beta - c} + \beta\right)\left[1 - \pi\frac{\beta(\beta - 2c)}{(\beta - c)^2}\right] - (1-\pi)U'\left(Y + W - \pi\frac{\beta^2}{\beta - c}\right)\pi\frac{\beta(\beta - 2c)}{(\beta - c)^2}$$

If the first order condition is positive at $\beta = W$, then the optimal benefit should be greater than W. Letting $\beta = W$ in the previous equation, we want to show that

$$\begin{aligned} 0 \quad < \quad & \pi U'\left(Y - \pi\frac{W^2}{W - c} + W\right)\left[1 - \pi\frac{W(W - 2c)}{(W - c)^2}\right] \\ & -(1-\pi)U'\left(Y + W - \pi\frac{W^2}{W - c}\right)\pi\frac{W(W - 2c)}{(W - c)^2} \end{aligned}$$

which simplifies to

$$0 < 1 - \frac{W(W - 2c)}{(W - c)^2}$$

This obviously holds since $c^2 > 0$.

is high enough. What is left to find is the impact of crime prevention.

Suppose the government can invest in crime prevention by turning Dares into Truths. That is to say that the government may prevent the incidence of crime in the economy by altering the distribution of types.[16] Suppose crime prevention is achieved by spending some amount X so that $\xi'_X < 0$ and $\xi''_{XX} > 0$. This amount X must come from taxes levied on the general population. Suppose this tax is collected using a poll tax. This means that some amount x is collected from each agent in the economy to finance investments in crime prevention (the total amount collected is then $X = Nx$, where N is the total number of agents in the economy).

To judge whether prevention is warranted we need to examine the impact of crime prevention on both parts of the contracts.

Proposition 6 *In the case where $\eta < 1$ and $\nu > 0$, the amount of crime is independent of ξ; it follows that, at the margin, crime prevention has no impact on crime. In the case where $\eta = 1$ and $\nu = 0$, the amount of crime decreases with ξ; it follows that crime prevention reduces crime.*

Proof: See appendix C. •

This proposition implies that if there are enough Dares in an economy then crime prevention (by increasing the morality of the population) will not be useful. Thus investment in crime prevention does not benefit anyone since the incidence of crime remains the same, while scarce resources are wasted. On the other hand, if $\xi < \xi^*$, Dares cheat with probability one. In this case, it is clear that by reducing the number of Dares in the economy we reduce the amount of crime. If there are N_D Dares in the economy and N total agents, and all Dares commit fraud, then the number of criminal acts committed is $(1-\pi)N_D$. If we are somehow able to change a Dare into a Truth, then the amount of crime becomes $(1-\pi)(N_D - 1)$. Therefore investing in crime prevention reduces crime. The question then becomes when is crime prevention warranted.

To answer this question, let us first examine the case where $\xi < \xi^*$. The problem faced by the principal is then

$$\begin{aligned} \max_{\beta, X} EU &= \pi U\left(Y + (1-\pi)\beta - \xi(X)(1-\pi)\beta - X\right) \\ &\quad + (1-\pi) U\left(Y + W - \pi\beta - \xi(X)(1-\pi)\beta - X\right) \end{aligned} \tag{28}$$

[16] For example, this can be achieved by buying commercial time on television and by putting up billboards that encourage honesty. The government can also organize crime prevention seminars to convince agents that crime does not pay.

The first order conditions give us

$$\frac{\partial EU}{\partial \beta} = 0 = \pi U'\left(Y + (1-\pi)\beta - \xi(X)(1-\pi)\beta - X\right)[1 - \pi - \xi(X)(1-\pi)] \qquad (29)$$
$$-(1-\pi)U'\left(Y + W - \pi\beta - \xi(X)(1-\pi)\beta - X\right)[\pi + \xi(X)(1-\pi)]$$

$$\frac{\partial EU}{\partial X} = 0 = -\pi U'\left(Y + (1-\pi)\beta - \xi(X)(1-\pi)\beta - X\right)\left[1 + \beta\xi'(X)(1-\pi)\right] \qquad (30)$$
$$-(1-\pi)U'\left(Y + W - \pi\beta - \xi(X)(1-\pi)\beta - X\right)\left[1 + \beta\xi'(X)(1-\pi)\right]$$

The solution is then given by

$$\frac{U'\left(Y - \pi\beta - \beta\xi(X)(1-\pi) + \beta - X\right)}{\left[\begin{array}{c}\pi U'\left(Y - \pi\beta - \beta\xi(X)(1-\pi) + \beta - X\right) \\ +(1-\pi)U'\left(Y + W - \pi\beta - \beta\xi(X)(1-\pi) - X\right)\end{array}\right]} = 1 + \xi(X)\left(\frac{1-\pi}{\pi}\right) \qquad (31)$$

and

$$-\xi'(X) = \frac{1}{(1-\pi)\beta} \qquad (32)$$

This means that the amount spent in prevention decreases as the probability of being unemployed increases ($\frac{\partial X}{\partial \pi} < 0$ since $\xi'' > 0$). Also, we have that the amount spent on prevention increases as the benefit increases ($\frac{\partial X}{\partial \beta} > 0$). The intuition behind $\frac{\partial X}{\partial \beta} > 0$ is that society should be more willing to invest in crime prevention by turning Dares into Truths when crime is more costly to society (higher β means that Dares receive more when they commit a crime).

As for $\frac{\partial X}{\partial \pi} < 0$, since more agents actually need the benefits, there is less need to change Dares into Truths since less crime will be committed. Another way to look at this is to say that when the economy turns bad (greater probability of losing one's employment), governments should investigate less since agents are no longer in a position to commit such crimes. We know that the amount of crime in society in the case where $\xi < \xi^*$ is given by $\xi(1-\pi)$. An increase in the probability of being unemployed reduces crime, which means that less money needs to be devoted to crime prevention.

Although we have here that the optimal level of crime prevention is positive, one must make sure that the resulting expected utility is greater than in the case where the optimal level of coverage solves

$$\frac{U'\left(Y - \pi\frac{\beta^2}{\beta - c} + \beta\right)}{\pi U'\left(Y - \pi\frac{\beta^2}{\beta - c} + \beta\right) + (1-\pi)U'\left(Y + W - \pi\frac{\beta^2}{\beta - c}\right)} = \frac{\beta(\beta - 2c)}{(\beta - c)^2} \qquad (33)$$

This is the solution to the maximization problem when the proportion of Dares is greater than ξ^*. Figure 6 illustrates what is happening. For crime prevention to be effective, the proportion of Dares has to be on the downward slopping portion of expected utility curve.[17] This is characterized by a translation of the entire utility frontier for all $\xi < \xi^*$. Crime prevention has two conflicting results on an agent's utility. First, an agent's expected utility is increased because the proportion of Dares decreases (provided the resulting proportion of Dares lies below ξ^*, otherwise an agent's expected utility is invariant). Second, an agent's expected utility is reduced because he must pay x dollars in taxes. It is therefore possible no crime prevention is warranted because a reduction in ξ is more than upset by an the increase in taxes. In fact investment in crime prevention is warranted only as long as

$$\left[\begin{array}{c}\pi U\left(Y+(1-\pi)\beta_x^*-\xi(X)(1-\pi)\beta_x^*-X\right)\\+(1-\pi)U\left(Y+W-\pi\beta_x^*-\xi(X)(1-\pi)\beta_x^*-X\right)\end{array}\right]>\left[\begin{array}{c}\pi U\left(Y-p_{\eta\nu}^*+\beta_{\eta\nu}^*\right)\\+(1-\pi)U\left(Y+W-p_{\eta\nu}^*\right)\end{array}\right] \quad (34)$$

Thus, depending on the efficiency of the crime prevention technology and on the initial proportion of Dares, investment in crime prevention is not necessarily advantageous. Obviously, the more efficient the technology, the greater the incentive to invest in crime prevention. For all proportions of Dares greater than ξ^*, the greater the proportion of Dares, the smaller the incentive to invest in crime prevention.

This second aspect of crime prevention is interesting in the sense that when there is a lot of criminal elements in the economy, investment in prevention is not useful. By reducing the number of Dares in the economy one increases the incentives for those who remain Dares to engage in criminal activities. In equilibrium, the two effects offset each other perfectly. Thus investing in crime prevention when $\xi >> \xi^*$ only reduces the agents' expected utility (because of the tax).

It is also possible to observe an increase in crime after investment in prevention if the resulting proportion of Dares remains greater then ξ^*. To see why, note that conditional on an agent being a Dare, the probability he commits a crime (given $\xi(X) > \xi^*$) is given by $\eta = \left(\frac{\pi}{1-\pi}\right)\left(\frac{c}{\beta(X)-c}\right)\frac{1}{\xi(X)}$. Given $\xi(X)$, the proportion of Dares, the unconditional probability of crime is $\eta_u = \left(\frac{\pi}{1-\pi}\right)\left(\frac{c}{\beta(X)-c}\right)$. This means that crime increases in the economy after investment in prevention if and only if $\frac{\partial\eta}{\partial X} = \frac{\partial\eta}{\partial\beta}\frac{\partial\beta}{\partial X} > 0$. Since $\frac{\partial\eta}{\partial\beta} < 0$, crime increases as investment in prevention increases if and only if $\frac{d\beta}{dX} < 0$. Using the envelope theorem, $\frac{d\beta}{dX} < 0$ indeed holds if and only if the

[17]For all $\xi > \xi^*$, there is no point in investing in crime prevention. Therefore, at the optimum, only the expected utility frontier for value $\xi < \xi^*$ will ever move downwards.

agent's utility function does not display increasing absolute risk aversion,[18].

4.3 Evolution

A straightforward extension to the model is to introduce evolutionary economics. Suppose that prior to the start of a game, agents must decide if they are Truths or Dares. An agent who chooses to be a Dare (Truth) must incur disutility Ξ_D (Ξ_T).

Suppose it is no more costly to be a Dare than a Truth ($\Xi_T \geq \Xi_D$). It is then always optimal to choose to be a Dare. To see why, consider the case where a large proportion of the population chooses to be a Dare (greater than ξ^*). In that case, the optimal contract is constant irrespective of the proportion of Dares, and thus the agent's expected utility is the same whether he chooses to be a Dare or a Truth. Given it is no more expensive to be a Dare (and possibly less expensive), every agent should choose to be a Dare. Now consider the case where few agents choose to be Dares (proportion lower than ξ^*). It is then possible to show that choosing to be a Dare yields greater expected utility than choosing to be a Truth. This occurs when

$$\begin{array}{c} \pi U\left(Y-p+\beta\right)+(1-\pi)(1-\eta)U\left(Y+W-p\right) \\ +(1-\pi)\eta(1-\nu)U\left(Y+W-p+\beta\right) \\ +(1-\pi)\eta\nu\left[U\left(Y+W-p\right)-k\right]-\Xi_D \end{array} \geq \begin{array}{c} (1-\pi)U\left(Y+W-p+\beta\right) \\ +\pi U\left(Y-p\right)-\Xi_T \end{array} \tag{35}$$

Since no agent is investigated when $\xi < \xi^*$ (see theorem 2), we have $\eta = 1$ and $\nu = 0$. Inequality 35 then always holds since $\beta > 0$ and $\Xi_T \geq \Xi_D$; which means that choosing to be a Truth is weakly dominated.

On the other hand, suppose it is more costly to be a Dare than to be a Truth ($\Xi_D > \Xi_T$). An agent may then prefer to be a Truth than a Dare. To see why, recall that the Truths' and the Dares' expected utility is the same at the optimum when $\xi > \xi^*$. Since it is more costly to be Dares, agents should choose to be Truths. This means that the maximum proportion of Dares in the economy must be ξ^*. Given this upper limit for ξ when $\Xi_D > \Xi_T$, and given that for all $\xi < \xi^*$, $\eta = 1$ and $\nu = 0$, we have that the long-run evolutionary proportion of Dares in the economy (ξ_{LR}) solves

$$\Xi_D - \Xi_T = \pi\left[U\left(Y - p\left(\xi_{LR}\right) + \beta\left(\xi_{LR}\right)\right) - U\left(Y - p\left(\xi_{LR}\right)\right)\right] \tag{36}$$

[18] Rewriting the first order condition as

$$\Omega = U'\left(Y - \pi\frac{\beta^2}{\beta - c} + \beta - x\right)\left[1 - \frac{\beta(\beta-2c)}{(\beta-c)^2}\right] + (1-\pi)U'\left(Y + W - \pi\frac{\beta^2}{\beta-c} - x\right)\frac{\beta(\beta-2c)}{(\beta-c)^2} = 0$$

we can show that $\frac{\partial\Omega}{\partial\beta} < 0$, and that $\frac{\partial\Omega}{\partial X} > 0$. This means that $\frac{d\beta}{dX} > 0$. Therefore we have $\frac{\partial\eta}{\partial X} > 0$.

From proposition 5 we know the solution to $\beta(\xi_{LR})$ and $p(\xi_{LR}) = [\pi + \xi_{LR}(1-\pi)]\beta(\xi_{LR})$. It is possible to show that the long-run evolutionary proportion of Dares in the economy is decreasing in the cost differential between becoming a Dare and becoming a Truth ($\frac{\partial \xi_{LR}}{\partial(\Xi_D - \Xi_T)} < 0$).

When we allow agents to choose their type before the game starts, it becomes interesting to note that prevention is positive if $\Xi_D - \Xi_T > 0$. If $\Xi_D - \Xi_T \leq 0$, investment in prevention may not occur, depending on the prevention technology. This is due to the fact that every agent chooses to be a Dare when $\Xi_D - \Xi_T \leq 0$, and that the crime is independent of the exact proportion of Dares when $\xi > \xi^*$ (see Proposition 6).

It follows that, given the choice, every agent will choose to be a Dare if it is no more costly to be a Dare than a Truth. This means that investment in crime prevention may be useless. On the other hand, if it is more costly to be a Dare, then the long-run evolutionary proportion of Dares in the economy will be between 0 and ξ^*. In this case, we know from the previous section that investment in prevention will be positive.

Clearly one agent's decision to commit crime depends one the decisions of others. If no one wanted to be a Dare, it would be optimal for an agent to become one since in that case the principal never investigates and the Dare can always commit a crime. If everyone wanted to be a Dare, and is the cost of being a Truth is not too large compared to being a Dare, then one agent would be better of to be a Truth. Using a different approach Jost (2001) also finds it would be best for agents to coordinate in committing crimes.

5 Conclusion

In this paper, we presented a principal-agent model where agents may be of two possible privately-known types. These types differ only with respect to the propensity to commit a crime. One type of agents, the Truth, always never commits a crime. The other type, the Dare, has no moral objection to committing a crime.

The main results of the paper are four-fold. First, there is no separating contract in this economy based on an agent's type. Second, if the proportion of Dares in the economy is large enough, then the pooling contract is independent of the exact proportion of Dares in the economy. Third, if the proportion of Dares in the economy is large enough, then the amount of crime and the number of condemned criminals is independent of the exact proportion of Dares in the economy. Finally, investment in prevention may have no impact on crime if there are too many Dares in the economy (or even increase crime under certain conditions on the utility function).

This last result has the interesting implication that investing in crime prevention may be a waste of resources. For example, commercials or billboards that intend to convince people not to commit crime by attacking the lack of morality of Dares is a misallocation of funds since such funds do not reduce crime, and they are an expenses for agents. This is true only when the proportion of Dares is large. When the proportion of Dares is small, investing in crime prevention will bear fruit. In this case, investment in prevention is greater when the economy is good (probability of being unemployed is smaller), the cost of investigating crime is higher and crime pays more (benefits are larger).

It is true that we modelled only one particular type of crime in this paper: contractual crime. We do not believe that our results may be transposed directly to physical crime (murder, rape, assault). Our simple model only claims to show that crime prevention and punishment may have no incidence on crime itself. Our result holds even if we let agents choose their type (Truth or Dare) before playing the crime game. Depending on the cost differential between being a Dare and being a Truth, we find what the long-run equilibrium proportion of criminal elements in the economy.

An aspect we did not approach in this paper is whether there are any political considerations to law enforcement. More precisely, it was always assumed here that the principal was always behaving in the Truth's best interest, and giving no weight to the Dare's utility. Applying Stigler's (1970) theory of political capture, Jost (1997) argues that it is in fact the political processes that specifies how much money is to be invested in crime prevention and law enforcement.

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7 Appendices

7.1 Appendix A

Proof of theorem 1: We can divide the proof in four parts.

PART 1. Suppose $\eta < 1$ and $\nu > 0$. In that case,

$$\eta = \left(\frac{\pi}{1-\pi}\right)\left(\frac{c}{\beta_D - c}\right) \tag{37}$$

and

$$\nu = \frac{U\left(Y+W-p_D+\beta_D\right) - U\left(Y+W-p_D\right)}{U\left(Y+W-p_D+\beta_D\right) - U\left(Y+W-p_D\right)+k} \tag{38}$$

By substituting (38) into (16) we obtain

$$\pi U\left(Y-p_D+\beta_D\right)+(1-\pi)U\left(Y+W-p_D\right) \geq \pi U\left(Y-p_T+\beta_T\right)+(1-\pi)U\left(Y+W-p_T+\beta_T\right) \tag{39}$$

Notice that the left hand side of (39) is equal to the right hand side of (17) This means that

$$\pi U\left(Y-p_T+\beta_T\right)+(1-\pi)U\left(Y+W-p_T\right) \geq \pi U\left(Y-p_T+\beta_T\right)+(1-\pi)U\left(Y+W-p_T+\beta_T\right) \tag{40}$$

which occurs only if $\beta_T = 0$, which does not happen as we show in proposition 3. Therefore (16) and (17) cannot hold at the same time, which means that no separating contracts exists.

PART 2. Suppose $\eta = 1$ and $\nu = 0$. The Lagrangian problem becomes

$$\begin{aligned}
\max_{\beta_T,p_T,\beta_D,p_D} EU_T \;=\; & \pi U\left(Y-p_T+\beta_T\right)+(1-\pi)U\left(Y+W-p_T\right) \qquad (41)\\
& +\lambda_{00}\left[\begin{array}{c}\pi U\left(Y-p_D+\beta_D\right)+(1-\pi)U\left(Y+W-p_D+\beta_D\right)\\ -\pi U(Y)-(1-\pi)U\left(Y+W\right)\end{array}\right]\\
& +\lambda_{01}\left[\begin{array}{c}\pi U\left(Y-p_T+\beta_T\right)+(1-\pi)U\left(Y+W-p_T\right)\\ -\pi U\left(Y\right)-(1-\pi)U(Y+W)\end{array}\right]\\
& +\lambda_{1}\left[\begin{array}{c}\pi U\left(Y-p_D+\beta_D\right)+(1-\pi)U\left(Y+W-p_D+\beta_D\right)\\ -\pi U\left(Y-p_T+\beta_T\right)-(1-\pi)U\left(Y+W-p_T+\beta_T\right)\end{array}\right]\\
& +\lambda_{2}\left[\begin{array}{c}\pi U\left(Y-p_T+\beta_T\right)+(1-\pi)U\left(Y+W-p_T\right)\\ -\pi U\left(Y-p_D+\beta_D\right)-(1-\pi)U\left(Y+W-p_D\right)\end{array}\right]\\
& +\lambda_3\left[p_T-\pi\beta_T\right]+\lambda_4\left[p_D-\beta_D\right]
\end{aligned}$$

The first order conditions of the problem are

$$\begin{aligned}
\frac{\partial EU_T}{\partial \beta_T} \;=\; & 0 = \pi U'\left(Y-p_T+\beta_T\right)\left(1+\lambda_2+\lambda_{01}\right)-\lambda_3\pi \qquad (42)\\
& -\lambda_1\left[\pi U'\left(Y-p_T+\beta_T\right)+(1-\pi)U'\left(Y+W-p_T+\beta_T\right)\right]
\end{aligned}$$

$$\frac{\partial EU_T}{\partial p_T} = 0 = -\left[\pi U'\left(Y - p_T + \beta_T\right) + (1-\pi)U'\left(Y + W - p_T\right)\right]\left(1 + \lambda_2 + \lambda_{01}\right) + \lambda_1\left[\pi U'\left(Y - p_T + \beta_T\right) + (1-\pi)U'\left(Y + W - p_T + \beta_T\right)\right] + \lambda_3 \tag{43}$$

$$\frac{\partial EU_T}{\partial \beta_D} = 0 = -\pi U'\left(Y - p_D + \beta_D\right)\lambda_2 - \lambda_4 + \left(\lambda_1 + \lambda_{00}\right)\left[\pi U'\left(Y - p_D + \beta_D\right) + (1-\pi)U'\left(Y + W - p_D + \beta_D\right)\right] \tag{44}$$

$$\frac{\partial EU_T}{\partial p_D} = 0 = \left[\pi U'\left(Y - p_D + \beta_D\right) + (1-\pi)U\left(Y + W - p_D\right)\right]\lambda_2 + \lambda_4 - \left(\lambda_1 + \lambda_{00}\right)\left[\pi U'\left(Y - p_D + \beta_D\right) + (1-\pi)U'\left(Y + W - p_D + \beta_D\right)\right] \tag{45}$$

to which we add the complementary slackness conditions

$$\lambda_{00}\left[\pi U\left(Y - p_D + \beta_D\right) + (1-\pi)U\left(Y + W - p_D + \beta_D\right) - \pi U(Y) - (1-\pi)U\left(Y + W\right)\right] = 0 \tag{46}$$

$$\lambda_{01}\left[\pi U\left(Y - p_T + \beta_T\right) + (1-\pi)U\left(Y + W - p_T\right) - \pi U\left(Y\right) - (1-\pi)U(Y + W)\right] = 0 \tag{47}$$

$$\lambda_1\left[\begin{array}{c}\pi U\left(Y - p_D + \beta_D\right) + (1-\pi)U\left(Y + W - p_D + \beta_D\right) \\ -\pi U\left(Y - p_T + \beta_T\right) - (1-\pi)U\left(Y + W - p_T + \beta_T\right)\end{array}\right] = 0 \tag{48}$$

$$\lambda_2\left[\begin{array}{c}\pi U\left(Y - p_T + \beta_T\right) + (1-\pi)U\left(Y + W - p_T\right) \\ -\pi U\left(Y - p_D + \beta_D\right) - (1-\pi)U\left(Y + W - p_D\right)\end{array}\right] = 0 \tag{49}$$

By adding equations 42 and 43 we obtain

$$\frac{\partial EU_T}{\partial \beta_T} + \frac{\partial EU_T}{\partial p_T} = -\left(1 + \lambda_2 + \lambda_{01}\right)(1-\pi)U'\left(Y + W - p_T\right) + \lambda_3(1-\pi) = 0 \tag{50}$$

and

$$\frac{\partial EU_T}{\partial \beta_D} + \frac{\partial EU_T}{\partial p_D} = \lambda_2(1-\pi)U'\left(Y + W - p_D\right) = 0 \tag{51}$$

by adding equations 44 and 45. This means that $\lambda_2 = 0$, and thus

$$\pi U\left(Y - p_T + \beta_T\right) + (1-\pi)U\left(Y + W - p_T\right) \geq \pi U\left(Y - p_D + \beta_D\right) + (1-\pi)U\left(Y + W - p_D\right) \tag{52}$$

Since $p_T = \pi\beta_T$ and $p_D = \beta_D$ from $\frac{\partial EU_T}{\partial \lambda_3} = 0$ and $\frac{\partial EU_T}{\partial \lambda_4} = 0$, we have $\lambda_3 > 0$ and $\lambda_4 > 0$. $p_D = \beta_D$ means that

$$\pi U\left(Y - p_D + \beta_D\right) + (1-\pi)U\left(Y + W - p_D + \beta_D\right) = \pi U(Y) + (1-\pi)U\left(Y + W\right) \tag{53}$$

There is therefore no loss in generality to let $\beta_D = 0$. From 48 we know that

$$\pi U\left(Y - p_D + \beta_D\right) + (1-\pi)U\left(Y + W - p_D + \beta_D\right) \geq \pi U\left(Y - p_T + \beta_T\right) + (1-\pi)U\left(Y + W - p_T + \beta_T\right) \tag{54}$$

Substituting 53 into 54 yields that

$$\pi U(Y)+(1-\pi)U(Y+W)\geq\pi U(Y-p_T+\beta_T)+(1-\pi)U(Y+W-p_T+\beta_T) \tag{55}$$

which is not possible unless $\beta_T=0$. If $\beta_T=0$ and $\beta_D=0$, then the contract is not separating.

<u>*PART 3*</u>. The third possibility is that $\nu>0$, and $\eta=1$. In that case the Lagrangian is

$$\begin{aligned}\max_{\beta_T,p_T,\beta_D,p_D,\nu} EU_T &= \pi U(Y-p_T+\beta_T)+(1-\pi)U(Y+W-p_T) \\ &+\lambda_{00}\begin{bmatrix}\pi U(Y-p_D+\beta_D)+(1-\pi)(1-\nu)U'(Y+W-p_D+\beta_D)\\ +(1-\pi)\nu\left[U(Y+W-p_D)-k\right]-\pi U(Y)-(1-\pi)U(Y+W)\end{bmatrix} \\ &+\lambda_{01}\begin{bmatrix}\pi U(Y-p_T+\beta_T)+(1-\pi)U(Y+W-p_T)\\ -\pi U(Y)-(1-\pi)U(Y+W)\end{bmatrix} \\ &+\lambda_1\begin{bmatrix}\pi U(Y-p_D+\beta_D)+(1-\pi)(1-\nu)U(Y+W-p_D+\beta_D)\\ +(1-\pi)\nu\left[U(Y+W-p_D)-k\right]\\ -\pi U(Y-p_T+\beta_T)-(1-\pi)U(Y+W-p_T+\beta_T)\end{bmatrix} \\ &+\lambda_2\begin{bmatrix}\pi U(Y-p_T+\beta_T)+(1-\pi)U(Y+W-p_T)\\ -\pi U(Y-p_D+\beta_D)-(1-\pi)U(Y+W-p_D)\end{bmatrix} \\ &+\lambda_3\left[p_T-\pi\beta_T\right]+\lambda_4\left[p_D-\pi\beta_D-(1-\pi)\beta_D(1-\nu)-c\nu\right]+\lambda_5\nu\end{aligned} \tag{56}$$

The first order conditions of this problem are

$$\begin{aligned}\frac{\partial EU_T}{\partial\beta_T} &= 0=\pi U'(Y-p_T+\beta_T)(1+\lambda_2+\lambda_{01})-\lambda_3\pi \\ &-\lambda_1\left[\pi U'(Y-p_T+\beta_T)+(1-\pi)U'(Y+W-p_T+\beta_T)\right]\end{aligned} \tag{57}$$

$$\begin{aligned}\frac{\partial EU_T}{\partial p_T} &= 0=-\left[\pi U'(Y-p_T+\beta_T)+(1-\pi)U'(Y+W-p_T)\right](1+\lambda_2+\lambda_{01}) \\ &+\lambda_1\left[\pi U'(Y-p_T+\beta_T)+(1-\pi)U'(Y+W-p_T+\beta_T)\right]+\lambda_3\end{aligned} \tag{58}$$

$$\begin{aligned}\frac{\partial EU_T}{\partial\beta_D} &= 0=-\pi U'(Y-p_D+\beta_D)\lambda_2-\lambda_4\left[\pi+(1-\pi)(1-\nu)\right] \\ &+(\lambda_1+\lambda_{00})\left[\pi U'(Y-p_D+\beta_D)+(1-\pi)(1-\nu)U'(Y+W-p_D+\beta_D)\right]\end{aligned} \tag{59}$$

$$\begin{aligned}\frac{\partial EU_T}{\partial p_D} &= 0=\left[\pi U'(Y-p_D+\beta_D)+(1-\pi)U(Y+W-p_D)\right]\lambda_2+\lambda_4 \\ &-(\lambda_1+\lambda_{00})\begin{bmatrix}\pi U'(Y-p_D+\beta_D)+(1-\pi)(1-\nu)U'(Y+W-p_D+\beta_D)\\ +(1-\pi)\nu U'(Y+W-p_D)\end{bmatrix}\end{aligned} \tag{60}$$

$$\frac{\partial EU_T}{\partial \nu} = 0 = \lambda_4(1-\pi)\beta_D + \lambda_5 + (\lambda_1+\lambda_{00})(1-\pi)\left[U(Y-p_D+W) - k - U(Y+W-p_D+\beta_D)\right] \tag{61}$$

Since $\lambda_5 = 0$ and $\lambda_4 > 0$, it has to be that $\lambda_1 + \lambda_{00} > 0$.

$$\frac{\partial EU_T}{\partial \beta_T} + \frac{\partial EU_T}{\partial p_T} = (1-\pi)\lambda_3 - (1-\pi)U'(Y+W-p_T)(1+\lambda_2+\lambda_{01}) = 0 \tag{62}$$

$$\frac{\partial EU_T}{\partial \beta_D} + \frac{\partial EU_T}{\partial p_D} = 0 = -\lambda_4\left[1-\pi-(1-\pi)(1-\nu)\right] + (1-\pi)U(Y+W-p_D)\lambda_2 - (\lambda_1+\lambda_{00})\left[(1-\pi)\nu U'(Y+W-p_D)\right] \tag{63}$$

If $\lambda_1 + \lambda_{00} > 0$, then $\lambda_2 > 0$. This means that

$$\pi U(Y-p_T+\beta_T) + (1-\pi)U(Y+W-p_T) = \pi U(Y-p_D+\beta_D) + (1-\pi)U(Y+W-p_D) \tag{64}$$

From the incentive compatibility constraint of the Dares, we know that

$$\begin{array}{c} \pi U(Y-p_D+\beta_D) \\ +(1-\pi)(1-\nu)U(Y+W-p_D+\beta_D) \\ +(1-\pi)\nu\left[U(Y+W-p_D)-k\right] \end{array} \geq \pi U(Y-p_T+\beta_T) + (1-\pi)U(Y+W-p_T+\beta_T) \tag{65}$$

Clearly,

$$\pi U(Y-p_T+\beta_T) + (1-\pi)U(Y+W-p_T+\beta_T) > \pi U(Y-p_T+\beta_T) + (1-\pi)U(Y+W-p_T) \tag{66}$$

Using 64 we have that

$$\pi U(Y-p_T+\beta_T) + (1-\pi)U(Y+W-p_T+\beta_T) > \pi U(Y-p_D+\beta_D) + (1-\pi)U(Y+W-p_D) \tag{67}$$

Substituting in 65 yields

$$\begin{array}{c} \pi U(Y-p_D+\beta_D) \\ +(1-\pi)(1-\nu)U(Y+W-p_D+\beta_D) \\ +(1-\pi)\nu\left[U(Y+W-p_D)-k\right] \end{array} > \pi U(Y-p_D+\beta_D) + (1-\pi)U(Y+W-p_D) \tag{68}$$

This means that

$$\begin{array}{c} \pi U(Y-p_D+\beta_D) + (1-\pi)(1-\nu)U(Y+W-p_D+\beta_D) \\ +(1-\pi)\nu\left[U(Y+W-p_D)-k\right] \end{array} > \pi U(Y) + (1-\pi)U(Y+W) \tag{69}$$

since

$$U(Y-p_D+\beta_D) + (1-\pi)U(Y+W-p_D) \geq \pi U(Y) + (1-\pi)U(Y+W) \tag{70}$$

Therefore, $\lambda_{00} = 0$. But since $\lambda_1 + \lambda_{00} > 0$, we thus have that $\lambda_1 > 0$. This means that

$$\begin{array}{c} \pi U\left(Y - p_D + \beta_D\right) \\ +(1-\pi)(1-\nu)U\left(Y + W - p_D + \beta_D\right) \\ +(1-\pi)\nu\left[U\left(Y + W - p_D\right) - k\right] \end{array} = \pi U\left(Y - p_T + \beta_T\right) + (1-\pi)U\left(Y + W - p_T + \beta_T\right) \quad (71)$$

Thus both type of agents are indifferent between the contract designed for their own type and the contract designed for the other's type. From our distribution-amongst-best contract assumption, this means that there is no separating contract in this third case.

PART 4. The fourth possibility is that $\nu = 0$, and $\eta < 1$.This case cannot be an equilibrium. Suppose the principal never investigates. Then agents have no risk of being caught committing a crime. Committing a crime always then becomes a dominating strategy; which means that $\eta = 1$. We know from Part 3 of the proof that such a contract is not separating.•

7.2 Appendix B

Proof of proposition 3: Suppose $\eta < 1$ and $\nu > 0$. In this game (whose extensive form is presented in figure 2),[19] the principal does not know if the contract was bought by a Truth or a Dare. The contract is bought by the Truth with probability $1-\xi$. When time comes for the principal to investigate or not, the only thing she knows is whether the agent requests unemployment benefits not. In other words, she does not know if she is facing a Dare who committed a crime, or a Truth who indeed suffered a loss. Her strategy in case the agent request no benefits is simple: she does not investigate.

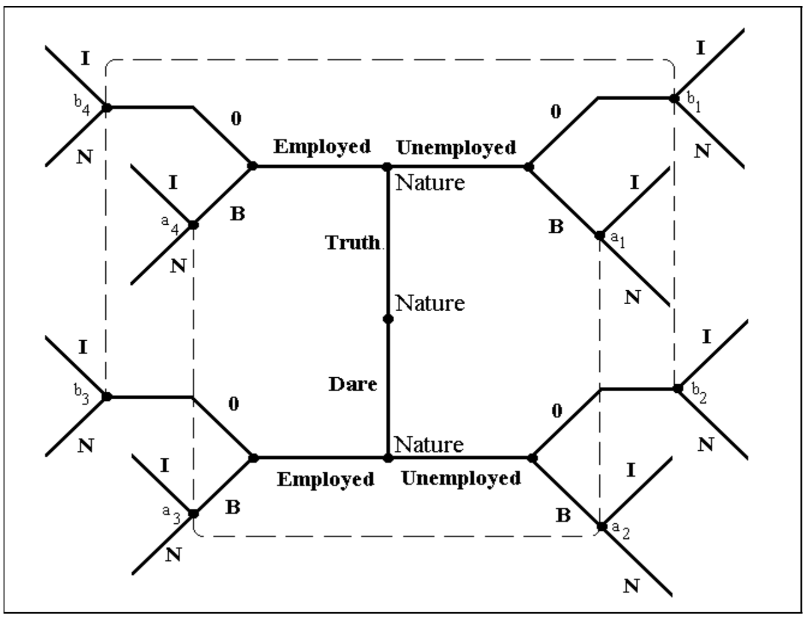

Figure 2: Extensive form of the game where agents know their type (Truth or Dare) and whether they are employed or not.

The principal's beliefs has to where she is in the game are given by

$$b_1 = 0 \tag{72}$$

$$b_2 = 0 \tag{73}$$

$$b_3 = \frac{\xi\,(1-\eta)}{(1-\xi)+\xi\,(1-\eta)} \tag{74}$$

[19] In this game, to ease notation, we let B represent that an agent requests UI benefits, 0 that he does not request UI benefits, I that the principal investigates the agent, and N that she does not investigate.

$$b_4 = \frac{1-\xi}{(1-\xi)+\xi(1-\eta)} \tag{75}$$

When a benefit is requested, her beliefs are given as

$$a_1 = \frac{\pi(1-\xi)}{\pi+\xi(1-\pi)\eta} \tag{76}$$

$$a_2 = \frac{\pi\xi}{\pi+\xi(1-\pi)\eta} \tag{77}$$

$$a_3 = \frac{\xi(1-\pi)\eta}{\pi+\xi(1-\pi)\eta} \tag{78}$$

$$a_4 = 0 \tag{79}$$

We see that those beliefs are affected by the agent's reporting strategy. For the principal to be indifferent between investigating or not when benefits are requested, the probability she assigns to a claim being fraudulent (a_3) must solve

$$\left(-c-\beta_{\eta\nu}\right)(1-a_3)+(-c)\,a_3 = -\beta_{\eta\nu} \tag{80}$$

where the left hand side represents the principal's expected payoff from investigating, and the right hand side is her payoff from not investigating. We then get that $a_3 = \frac{c}{\beta_{\eta\nu}}$.

Using (78), the probability that a Dare commits a crime is given by[20]

$$\eta = \frac{\pi}{(1-\pi)\xi}\left(\frac{c}{\beta_{\eta\nu}-c}\right) \tag{81}$$

The principal investigates with probability

$$\nu = \frac{U\left(Y+W-p_{\eta\nu}+\beta_{\eta\nu}\right)-U\left(Y+W-p_{\eta\nu}\right)}{U\left(Y+W-p_{\eta\nu}+\beta_{\eta\nu}\right)-U\left(Y+W-p_{\eta\nu}\right)+k} \tag{82}$$

The beliefs of the principal in each information node are then

$$a_1 = (1-\xi)\frac{\beta_{\eta\nu}-c}{\beta_{\eta\nu}} \tag{83}$$

$$a_2 = \xi\frac{\beta_{\eta\nu}-c}{\beta_{\eta\nu}} \tag{84}$$

$$a_3 = \frac{c}{\beta_{\eta\nu}} \tag{85}$$

$$a_4 = b_1 = b_2 = 0 \tag{86}$$

[20]To get a meaningful probability (i.e.: between zero and one), it has to be that $\xi > \frac{\pi}{1-\pi}\left(\frac{c}{\beta-c}\right)$.

$$b_3 = \frac{\xi\,(1-\pi)\left(\beta_{\eta\nu}-c\right)-c}{(1-\pi)\,\beta_{\eta\nu}-c} \tag{87}$$

$$b_4 = \frac{(1-\xi)\,(1-\pi)\left(\beta_{\eta\nu}-c\right)}{(1-\pi)\,\beta_{\eta\nu}-c} \tag{88}$$

Note that for (87) and (88) to be between zero and one the proportion of Dares, ξ, must be larger than $\frac{\pi}{1-\pi}\left(\frac{c}{\beta_{\eta\nu}-c}\right)$. This fraction is the same as the one needed to have $\eta < 1$.

The premium that yields zero-profit is given by

$$p_{\eta\nu} = (1-\xi)\,\pi\left(\beta_{\eta\nu}+c\nu\right)+\xi\left[\pi\beta_{\eta\nu}+(1-\pi)\beta_{\eta\nu}\eta\,(1-\nu)+c\nu[\pi+(1-\pi)\eta]\right] \tag{89}$$

The problem faced by the principal is then

$$\max_{p_{\eta\nu},\beta_{\eta\nu}} EU_{\eta\nu} = \pi U\left(Y-p_{\eta\nu}+\beta_{\eta\nu}\right)+(1-\pi)U\left(Y+W-p_{\eta\nu}\right) \tag{90}$$

subject to

$$p_{\eta\nu} = (1-\xi)\,\pi\left(\beta_{\eta\nu}+c\nu\right)+\xi\left[\pi\beta_{\eta\nu}+(1-\pi)\beta_{\eta\nu}\eta\,(1-\nu)+c\nu[\pi+(1-\pi)\eta]\right] \tag{91}$$

$$\eta = \frac{1}{\xi}\left(\frac{\pi}{1-\pi}\right)\left(\frac{c}{\beta_{\eta\nu}-c}\right) \tag{92}$$

$$\nu = \frac{U(Y+W-p_{\eta\nu}+\beta_{\eta\nu})-U(Y+W-p_{\eta\nu})}{U(Y+W-p_{\eta\nu}+\beta_{\eta\nu})-U(Y+W-p_{\eta\nu})+k} \tag{93}$$

Substituting for the PBNE constraints yields

$$\max_{p_{\eta\nu},\beta_{\eta\nu}} EU_{\eta\nu} = \pi U\left(Y-p_{\eta\nu}+\beta_{\eta\nu}\right)+(1-\pi)U\left(Y+W-p_{\eta\nu}\right) \tag{94}$$

subject to

$$p_{\eta\nu} = \pi\frac{\beta_{\eta\nu}^2}{\beta_{\eta\nu}-c} \tag{95}$$

This maximization problem is exactly the same that the Criminal faces in an economy with full information (see equation 10 and lemma 1). We can therefore say that if $\xi > \overline{\xi} = \frac{\pi}{1-\pi}\left(\frac{c}{\beta_{\eta\nu}-c}\right)$, then the contract does not vary with the proportion of Dares in the economy.•

Proof of proposition 4: Suppose $\eta = 1$ and $\nu > 0$. This means that the problem faced by the principal is

$$\max_{p_{0\nu},\beta_{0\nu},\nu_{0\nu}} EU_{0\nu} = \pi U\left(Y-p_{0\nu}+\beta_{0\nu}\right)+(1-\pi)U\left(Y+W-p_{0\nu}\right) \tag{96}$$

subject to

$$p_{0\nu} = (1-\xi)\,\pi\beta_{0\nu} + \xi\left[\pi\beta_{0\nu} + (1-\pi)\beta_{0\nu}\,(1-\nu_{0\nu})\right] + c\nu\left[\xi + \pi(1-\xi)\right] \tag{97}$$

Letting $\lambda_{0\nu}$ be the Lagrange multiplier, the first order conditions of this program are

$$\frac{\partial EU_{0\nu}}{\partial p_{0\nu}} = 0 = -\left[\pi U'\left(Y - p_{0\nu} + \beta_{0\nu}\right) + (1-\pi)U'\left(Y + W - p_{0\nu}\right)\right] + \lambda_{0\nu} \tag{98}$$

$$\frac{\partial EU_{0\nu}}{\partial \beta_{0\nu}} = 0 = \pi U'\left(Y - p_{0\nu} + \beta_{0\nu}\right) - \lambda_{0\nu}\left[\pi + \xi\,(1-\pi)\,(1-\nu_{0\nu})\right] \tag{99}$$

$$\frac{\partial EU_{0\nu}}{\partial \nu_{0\nu}} = 0 = \lambda_{0\nu}\left[\xi\,(1-\pi)\,\beta_{0\nu} - c\,(\xi + \pi\,(1-\xi))\right] \tag{100}$$

Solving yields the desired results.•

Proof of proposition 5: Suppose $\eta = 1$ and $\nu = 0$. This means that the problem faced by the principal is

$$\max_{p_{00},\beta_{00}} EU_{00} = \pi U\left(Y - p_{00} + \beta_{00}\right) + (1-\pi)U\left(Y + W - p_{00}\right) \tag{101}$$

subject to

$$p_{00} = (1-\xi)\,\pi\beta_{00} + \xi\beta_{00} \tag{102}$$

Letting λ_{00} be the Lagrange multiplier, the first order conditions of this program are

$$\frac{\partial EU_{00}}{\partial p_{00}} = 0 = -\left[\pi U'\left(Y - p_{00} + \beta_{00}\right) + (1-\pi)U'\left(Y + W - p_{00}\right)\right] + \lambda_{00} \tag{103}$$

$$\frac{\partial EU_{00}}{\partial \beta_{00}} = 0 = \pi U'\left(Y - p_{00} + \beta_{00}\right) - \lambda_{00}\left[\pi\,(1-\xi) + \xi\right] \tag{104}$$

Solving gives us

$$\frac{U'\left(Y - p_{00} + \beta_{00}\right)}{\pi U'\left(Y - p_{00} + \beta_{00}\right) + (1-\pi)U'\left(Y + W - p_{00}\right)} = 1 + \xi\frac{1-\pi}{\pi} \tag{105}$$

which is what we wanted.•

7.3 Appendix C

Proof of theorem 2: Define

$$\begin{aligned} EU_{00} &= \pi U\left(Y - p^*_{00} + \beta^*_{00}\right) + (1-\pi)U\left(Y + W - p^*_{00}\right) \\ EU_{0\nu} &= \pi U\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) + (1-\pi)U\left(Y + W - p^*_{0\nu}\right) \\ EU_{\eta\nu} &= \pi U\left(Y - p^*_{\eta\nu} + \beta^*_{\eta\nu}\right) + (1-\pi)U\left(Y + W - p^*_{\eta\nu}\right) \end{aligned}$$

This proof has three parts. First, we will show that $EU_{00} \geq EU_{0\nu}$ for all ξ. We will then show that there exists a $\widetilde{\xi}$ such that for all $\xi \leq \widetilde{\xi}$, $EU_{00} \geq EU_{\eta\nu}$, and for all $\xi \geq \widetilde{\xi}$, $EU_{00} \leq EU_{\eta\nu}$. Finally, we will show that $\widetilde{\xi} > \overline{\xi} = \frac{\pi}{1-\pi}\left(\frac{c}{\beta_{\eta\nu}-c}\right)$.

PART 1. For this part of the proof, we will use an optimal-value approach. We want to show that

$$EU_{00} - EU_{0\nu} = \left[\begin{array}{c} \pi U\left(Y - p^*_{00} + \beta^*_{00}\right) + (1-\pi)U\left(Y + W - p^*_{00}\right) \\ -\pi U\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) - (1-\pi)U\left(Y + W - p^*_{0\nu}\right) \end{array}\right] \geq 0 \tag{106}$$

always holds for any value of c, and that it is continuous.

Let us find the point where $EU_{00} - EU_{0\nu}$ is the smallest (in other words let us find the minimum of $EU_{00} - EU_{0\nu}$). The partial derivative of $EU_{00} - EU_{0\nu}$ with respect to c is

$$\begin{aligned} \frac{\partial\left(EU_{00} - EU_{0\nu}\right)}{\partial c} &= -\frac{\partial p^*_{00}}{\partial c}\left[\pi U'\left(Y - p^*_{00} + \beta^*_{00}\right) + (1-\pi)U'\left(Y + W - p^*_{00}\right)\right] \\ &\quad + \frac{\partial \beta^*_{00}}{\partial c}\pi U\left(Y - p^*_{00} + \beta^*_{00}\right) - \frac{\partial \beta^*_{0\nu}}{\partial c}\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) \\ &\quad + \frac{\partial p^*_{0\nu}}{\partial c}\left[\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) + (1-\pi)U'\left(Y + W - p^*_{0\nu}\right)\right] \end{aligned} \tag{107}$$

This is continuous for all $c > 0$.

$$\begin{aligned} \frac{\partial\left(EU_{00} - EU_{0\nu}\right)}{\partial c} &= \frac{\partial p^*_{0\nu}}{\partial c}\left[\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) + (1-\pi)U'\left(Y + W - p^*_{0\nu}\right)\right] \\ &\quad - \frac{\partial \beta^*_{0\nu}}{\partial c}\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) \end{aligned} \tag{108}$$

Since $\frac{\partial p^*_{00}}{\partial c} = \frac{\partial \beta^*_{00}}{\partial c} = 0$. We know that $\frac{\partial p^*_{0\nu}}{\partial c} = \left[\pi\left(1-\xi\right) + \xi\right]\frac{\partial \beta^*_{0\nu}}{\partial c}$ since $p^*_{0\nu} = \left[\pi\left(1-\xi\right) + \xi\right]\beta^*_{0\nu}$. We also know that $\frac{\partial \beta^*_{0\nu}}{\partial c} = \frac{\xi + (1-\xi)\pi}{\xi(1-\pi)} > 0$ since $\beta^*_{0\nu} = c\left[\frac{\pi}{(1-\pi)\xi} + 1\right]$. This means that $\frac{\partial^2 p^*_{0\nu}}{\partial c^2} = \frac{\partial^2 \beta^*_{0\nu}}{\partial c^2} = 0$. This yields

$$\begin{aligned} \frac{\partial\left(EU_{00} - EU_{0\nu}\right)}{\partial c} &= \left[\pi\left(1-\xi\right) + \xi\right]\frac{\partial \beta^*_{0\nu}}{\partial c}\left[\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) + (1-\pi)U'\left(Y + W - p^*_{0\nu}\right)\right] \\ &\quad - \frac{\partial \beta^*_{0\nu}}{\partial c}\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) \end{aligned} \tag{109}$$

Finding the optimum gives us

$$\frac{U'\left(Y-p_{0\nu}^{*}+\beta_{0\nu}^{*}\right)}{\pi U'\left(Y-p_{0\nu}^{*}+\beta_{0\nu}^{*}\right)+(1-\pi)U'\left(Y+W-p_{0\nu}^{*}\right)}=1+\xi\frac{(1-\pi)}{\pi} \tag{110}$$

which is the solution to Proposition 5 (equation 25). We know that the only optimum of $EU_{00}-EU_{0\nu}$ is found at the equilibrium value of $\eta=1$ and $\nu=0$. This means that $EU_{00}-EU_{0\nu}$ reaches an optimum where $EU_{00}-EU_{0\nu}=0$. Finding whether this is a minimum will tell us whether $EU_{00}-EU_{0\nu}$ holds away from this point. For a minimum, we want to have $\frac{\partial^2(EU_{00}-EU_{0\nu})}{\partial c^2}>0$.

Solving the second order condition yields

$$\begin{aligned}\frac{\partial^2\left(EU_{00}-EU_{0\nu}\right)}{\partial c^2} &= -\frac{\partial^2\beta_{0\nu}^{*}}{\partial c^2}\pi U'\left(Y-p_{0\nu}^{*}+\beta_{0\nu}^{*}\right)-\frac{\partial\beta_{0\nu}^{*}}{\partial c}\left[\frac{\partial\beta_{0\nu}^{*}}{\partial c}-\frac{\partial p_{0\nu}^{*}}{\partial c}\right]\pi U'\left(Y-p_{0\nu}^{*}+\beta_{0\nu}^{*}\right) \\ &\quad+\frac{\partial^2 p_{0\nu}^{*}}{\partial c^2}\left[\pi U'\left(Y-p_{0\nu}^{*}+\beta_{0\nu}^{*}\right)+(1-\pi)U'\left(Y+W-p_{0\nu}^{*}\right)\right] \\ &\quad+\frac{\partial p_{0\nu}^{*}}{\partial c}\left[\pi\left[\frac{\partial\beta_{0\nu}^{*}}{\partial c}-\frac{\partial p_{0\nu}^{*}}{\partial c}\right]U'\left(Y-p_{0\nu}^{*}+\beta_{0\nu}^{*}\right)-(1-\pi)\frac{\partial p_{0\nu}^{*}}{\partial c}U'\left(Y+W-p_{0\nu}^{*}\right)\right]\end{aligned} \tag{111}$$

Since $\frac{\partial^2 p_{0\nu}^{*}}{\partial c^2}=\frac{\partial^2\beta_{0\nu}^{*}}{\partial c^2}=0$, we have

$$\frac{\partial^2\left(EU_{00}-EU_{0\nu}\right)}{\partial c^2}=-\left(\frac{\partial\beta_{0\nu}^{*}}{\partial c}-\frac{\partial p_{0\nu}^{*}}{\partial c}\right)^2\pi U''\left(Y-p_{0\nu}^{*}+\beta_{0\nu}^{*}\right)-\left(\frac{\partial p_{0\nu}^{*}}{\partial c}\right)^2(1-\pi)\,U''\left(Y+W-p_{0\nu}^{*}\right)>0 \tag{112}$$

Which means that $EU_{00}-EU_{0\nu}$ reaches a minimum at

$$\frac{U'\left(Y-p_{0\nu}^{*}+\beta_{0\nu}^{*}\right)}{\pi U'\left(Y-p_{0\nu}^{*}+\beta_{0\nu}^{*}\right)+(1-\pi)U'\left(Y+W-p_{0\nu}^{*}\right)}=1+\xi\frac{(1-\pi)}{\pi} \tag{113}$$

which is where $\nu=0$.•

PART 2. In the second part of the proof we want to show that there exists a $\widetilde{\xi}\in[0,1]$ such that for all $\xi\leq\widetilde{\xi}$

$$EU_{00}-EU_{\eta\nu}=\left[\begin{array}{c}\pi U\left(Y-p_{00}^{*}+\beta_{00}^{*}\right)+(1-\pi)U\left(Y+W-p_{00}^{*}\right)\\ -\pi U\left(Y-p_{\eta\nu}^{*}+\beta_{\eta\nu}^{*}\right)-(1-\pi)U\left(Y+W-p_{\eta\nu}^{*}\right)\end{array}\right]\geq 0 \tag{114}$$

and that for all $\xi\geq\widetilde{\xi}$

$$EU_{00}-EU_{\eta\nu}=\left[\begin{array}{c}\pi U\left(Y-p_{00}^{*}+\beta_{00}^{*}\right)+(1-\pi)U\left(Y+W-p_{00}^{*}\right)\\ -\pi U\left(Y-p_{\eta\nu}^{*}+\beta_{\eta\nu}^{*}\right)-(1-\pi)U\left(Y+W-p_{\eta\nu}^{*}\right)\end{array}\right]\leq 0 \tag{115}$$

When $\xi=0$, $EU_{00}-EU_{\eta\nu}$ is obviously positive since EU_{00} gives us the first best allocation ($\beta_{00}^{*}=W$). When $\xi=1$, $EU_{00}-EU_{\eta\nu}$ is always negative since EU_{00} gives us at best the autarchic allocation ($EU_{00}=\pi U(Y)+(1-\pi)U(Y+W)$) since $p_{00}=\beta_{00}$ when $\xi=1$. If $EU_{00}-EU_{\eta\nu}$

is continuous on the $\xi \in [0,1]$ interval, then there must be a $\overline{\xi}$ such that $EU_{00} - EU_{\eta\nu} = 0$. Furthermore, if $EU_{00} - EU_{\eta\nu}$ is monotone, then this $\overline{\xi}$ is unique. To find whether $EU_{00} - EU_{\eta\nu}$ is continuous and monotone, we will use the first derivative of $EU_{00} - EU_{\eta\nu}$ with respect to ξ. This gives us

$$\begin{aligned}\frac{\partial\left(EU_{00}-EU_{\eta\nu}\right)}{\partial\xi} &= \pi U\left(Y-p_{00}^{*}+\beta_{00}^{*}\right)\left[\frac{\partial\beta_{00}^{*}}{\partial\xi}-\frac{\partial p_{00}^{*}}{\partial\xi}\right]+(1-\pi)U\left(Y+W-p_{00}^{*}\right)\left[-\frac{\partial p_{00}^{*}}{\partial\xi}\right] \\ &\quad -\pi U\left(Y-p_{\eta\nu}^{*}+\beta_{\eta\nu}^{*}\right)\left[\frac{\partial\beta_{\eta\nu}^{*}}{\partial\xi}-\frac{\partial p_{\eta\nu}^{*}}{\partial\xi}\right]-(1-\pi)U\left(Y+W-p_{\eta\nu}^{*}\right)\left[-\frac{\partial p_{\eta\nu}^{*}}{\partial\xi}\right]\end{aligned} \tag{116}$$

We know from Proposition 3 that $\frac{\partial\beta_{\eta\nu}^{*}}{\partial\xi}=\frac{\partial p_{\eta\nu}^{*}}{\partial\xi}=0$. We know that $\frac{\partial p_{00}^{*}}{\partial c}$ and $\frac{\partial\beta_{00}^{*}}{\partial c}$ are continuous in ξ since $p_{00}^{*}=\left[\pi\left(1-\xi\right)+\xi\right]\beta_{00}^{*}$, and β_{00}^{*} solves

$$\frac{U'\left(Y-\left[\pi\left(1-\xi\right)+\xi\right]\beta_{00}^{*}+\beta_{00}^{*}\right)}{\pi U'\left(Y-\left[\pi\left(1-\xi\right)+\xi\right]\beta_{00}^{*}+\beta_{00}^{*}\right)+(1-\pi)U'\left(Y+W-\left[\pi\left(1-\xi\right)+\xi\right]\beta_{00}^{*}\right)}=1+\xi\frac{1-\pi}{\pi} \tag{117}$$

All that is left to show is that $\frac{\partial(EU_{00}-EU_{\eta\nu})}{\partial\xi}\leq 0$. This occurs if and only if

$$0\geq\pi U\left(Y-p_{00}^{*}+\beta_{00}^{*}\right)\left[\frac{\partial\beta_{00}^{*}}{\partial\xi}-\frac{\partial p_{00}^{*}}{\partial\xi}\right]+(1-\pi)U\left(Y+W-p_{00}^{*}\right)\left[-\frac{\partial p_{00}^{*}}{\partial\xi}\right] \tag{118}$$

and

$$\frac{\partial\beta_{00}^{*}}{\partial\xi}\leq\frac{\beta_{00}^{*}}{1+\xi\frac{1-\pi}{\pi}} \tag{119}$$

which is always true since $\frac{\partial\beta_{00}^{*}}{\partial\xi}<0$. Therefore there must exist a $\widetilde{\xi}$ such that for all $\xi\leq\widetilde{\xi}$, $EU_{00}-EU_{\eta\nu}\geq 0$ and that for all $\xi\geq\widetilde{\xi}$, $EU_{00}-EU_{\eta\nu}\leq 0$•

PART 3. In the last part of the proof, we want to show that $\widetilde{\xi}>\overline{\xi}=\frac{\pi}{1-\pi}\left(\frac{c}{\beta_{\eta\nu}-c}\right)$. Suppose $\xi=\overline{\xi}$. Then it is clear that $EU_{0\nu}=EU_{\eta\nu}$ since by definition $\eta=1$ for all $\xi\leq\overline{\xi}$. We know that $EU_{00}>EU_{0\nu}$ for any ξ. This means that at $\xi=\overline{\xi}$, $EU_{00}>EU_{\eta\nu}$. Since we know that for all $\xi\leq\widetilde{\xi}$, $EU_{00}\geq EU_{\eta\nu}$, and for all $\xi\geq\widetilde{\xi}$, $EU_{00}\leq EU_{\eta\nu}$ it follows that $\overline{\xi}<\widetilde{\xi}$ since $EU_{\eta\nu}=EU_{0\nu}\leq EU_{00}$ at $\xi=\overline{\xi}$. This completes the proof.•

Proof of proposition 6: Again, we can divide this proof into two parts.

PART 1. Suppose we are in the case where $\xi>\overline{\xi}=\frac{\pi}{1-\pi}\left(\frac{c}{\beta_{\eta\nu}-c}\right)$. We know when there are no Truths in the economy that the expected probability that a Dare commits a crime is

$$E(\eta)=\eta=\left(\frac{\pi}{1-\pi}\right)\left(\frac{c}{\beta-c}\right) \tag{120}$$

When there are Truths, but that the proportion of Dares is greater than $\overline{\xi}$, the probability of fraud conditional on an agent being a Dare is

$$E(\eta/D) = \frac{\pi}{(1-\pi)\,\xi}\left(\frac{c}{\beta - c}\right) \tag{121}$$

When we include the fact that the probability that a contract is bought by a Criminal is given by ξ, we get that the probability that a fraudulent claim is filed is equal to

$$E(\eta) = \xi \frac{\pi}{(1-\pi)\xi}\left(\frac{c}{\beta - c}\right) = \eta \tag{122}$$

This means that whatever the proportion of Truths in the economy, the probability a crime is committed is constant. As for the probability that a crime is successful, it is straightforward to see that it is also independent of the proportion of Dares in the economy. We know the probability of investigation is independent of the proportion of each type of agent in the economy.

$$\nu = \frac{U(Y+W-p+\beta) - U(Y+W-p)}{U(Y+W-p+\beta) - U(Y+W-p) + k} \tag{123}$$

We also know that the probability of investigation and the probability of committing a crime a fraudulent claim are independent of the proportion of Truths. It then follows that the probability a crime remains undetected must also be independent of the proportion of Truths

PART 2. In the second case, when $\xi \leq \overline{\xi} = \frac{\pi}{1-\pi}\left(\frac{c}{\beta_{\eta\nu} - c}\right)$, the probability of fraud conditional on an agent being a Dare is one (they all cheat). In that case the overall probability of fraud is ξ. As for the probability that a crime is successful, it is straightforward to see that it is also independent of the proportion of Dares in the economy since no investiagtion is ever conducted when $\xi \leq \overline{\xi}$. •

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