

# Resistance (to Fraud) is Futile\*

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## Abstract

This paper studies a static principal-agent model of *insurance fraud* using a costly state verification approach. 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, I show that no separating contract exists. The optimal pooling contract can then be divided into two parts. For a proportion of Dares ( $\xi$ ) smaller than some  $\xi^*$ , the agents' expected utility decreases as the proportion of Dares ( $\xi$ ) increases. For a proportion greater than  $\xi^*$ , the agents' expected utility is independent of the exact proportion of Dares. In both cases the fixed punishment inflicted to Dares found to have committed fraud has no impact on the optimal contract. Investment in prevention is always beneficial if  $\xi < \xi^*$ . On the other hand, when  $\xi > \xi^*$ , investment in prevention may have no impact on fraud, depending on prevention technology and the initial proportion of Dares.

JEL classification: G22, C72, D82, D11.

Keywords: Insurance fraud, Fraud prevention, Non-commitment, Adverse selection.

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# Resistance (to Fraud) is Futile

Abstract. This paper studies a static principal-agent model of *insurance fraud* using a costly state verification approach. 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, I show that no separating contract exists. The optimal pooling contract can then be divided into two parts. For a proportion of Dares ( $\xi$ ) smaller than some  $\xi^*$ , the agents' expected utility decreases as the proportion of Dares ( $\xi$ ) increases. For a proportion greater than  $\xi^*$ , the agents' expected utility is independent of the exact proportion of Dares. In both cases the fixed punishment inflicted to Dares found to have committed fraud has no impact on the optimal contract. Investment in prevention is always beneficial if  $\xi < \xi^*$ . On the other hand, when  $\xi > \xi^*$ , investment in prevention may have no impact on fraud, depending on prevention technology and the initial proportion of Dares.

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# 1 Introduction

Crime, crime prevention and crime punishment have always represented a major concern of any society. In the United States, almost seven percent of the male workforce is under the supervision of the American penal system: two percent of the male workforce is incarcerated whereas another five percent is on probation or parole. Freeman (1996) compares these numbers to the long-term unemployment rates in Western Europe. In December 2001 *Scientific American* reported that the prison population in the United States approached 2.1 million in 2000. Compared to the 50 states, the U.S. prison system ranks 17th in terms of population, next to Nevada.

Close to 2% of the U.S. prison population (63,000 Americans) was incarcerated subsequent to a fraud conviction. Fraud is a relatively common crime in the United States. In automobile insurance, the rule of thumb is that insurance fraud represents 10 % of total claims (see Weisberg and Derrig, 1991, and Dionne and Gagné, 2002). If this is correct, and given that the total automobile insurance premium written annually in the United States is 110 billion dollars (see NAIC, 2001), the total cost to American policyholders of insurance fraud amounts to almost 11 billion dollars annually. Assuming this amount remains constant over time, the present value (using a 5% discount rate) of automobile insurance fraud in the United States is 220 billions dollars, which is almost three time the stock market value of Enron at the end of 2000. Without even considering unemployment insurance fraud, worker's compensation fraud and other types of fraud in medicine or in property damage, one could say that automobile insurance fraud is one of the most costly fraud scandals in the history of the United States.

The sheer size of the dollar value associated with insurance fraud begs the question of how we can fight this type of behavior? If insurance fraud is a crime, Becker (1968) suggests that, as for any crime, the government set the penalty to be very large, so that the probability of anyone committing one would be very small (see also Ehrlich, 1973, and Friedman, 1999).<sup>1</sup> In an insurance context, however, Becker's philosopher-king approach, with an infinite penalty and a commitment to a pre-specified investigation policy,<sup>2</sup> cannot hold for two reasons.

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<sup>1</sup>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 (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. 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.

<sup>2</sup>See Saha and Poole (2000) and Reinganum (2000) for a recent assessment of sentencing guidelines and penalties.

Firstly, penalties are not set to infinity and are usually determined by the courts. It is thus inappropriate to assume that the penalty is decided by the principal. Secondly, as argued by Besanko and Spulber (1989), it is not reasonable to assume that the principal can commit perfectly to verify the agent's action. The reason is that, after the agent has announced his type, both players have an incentive to renegotiate their agreement to save on the audit cost.

A consequence of the principal's inability to commit is that the informed agent's optimal strategy may be to misreport the state of the world. The models developed by Graetz, Reinganum and Wilde (1986), Sanchez and Sobel (1993), 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. The problems related to the sequential enforcement process is also studied in Shavel (1991) and Jost (1997).

To simplify the problem, I will use a one-period model similar to that of Townsend (1979), where privately informed agents have a monetary incentive to commit insurance fraud because investigation by the principal is costly. Moreover, and again for simplicity, all players have only two possible actions they can take: The agents may *commit fraud* or *be honest*, whereas the principal may *investigate the agent* or *not investigate*. Committing fraud exposes the agent to a penalty if he is caught by the principal.<sup>3</sup> This modelling approach can be applied to many insurance frameworks (see Mookherjee and Png, 1989, Picard, 1996, Bond and Crocker, 1997, and Boyer, 2000) such as automobile insurance, social security, health insurance and unemployment insurance. Reinganum and Wilde (1985) also use this approach to study income tax fraud.

The model includes implicitly an agent's propensity to commit fraud. Graetz, Reinganum and Wilde (1986) view this propensity difference in an income tax context as having some agents who are strategic compliers (may misreport), while others who are habitual compliers (never misreport). Picard (1996) presents a similar model in an insurance context. In my paper, the agents who never play the game (propensity is zero) are called the **Truths**, and the agents who dare play the fraud-game are called the **Dares**. I model prevention as a device that turns Dares into Truths.

The results of the paper are the following. First, if the principal cannot commit, then she will not be able to design a contract that separates the Truths from the Dares. The pooling contract is such that, when the proportion of Dares (given by  $\xi$ ) is smaller than some  $\xi^*$ , the agents' expected

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<sup>3</sup>Although my analysis is purely static as the game is played only once after which the players die, I partially address dynamic considerations in Section 6.2. The main results do not vary significantly.

utility decreases as the proportion of Dares increases. For a proportion of Dares greater than  $\xi^*$ , the pooling contract is independent of the exact proportion of Dares so that the agents' expected utility is independent of the exact proportion of Dares. In this case, investment in fraud prevention has no impact on the amount of fraud.

The paper is constructed as follows. In the next section, I present the setup of the game between the agents and the principal. In Section 3 I present the benchmark case where each agent's type is common knowledge. I let each agent's type be private information in Section 4 and I derive and discuss the optimal contract as a function of the proportion of criminal elements in the economy. I introduce the particular fraud prevention technology in Section 5. Section 6 briefly discusses dynamic considerations. Section 7 concludes and leaves room for further research.

## 2 Assumptions and Setup

In an unemployment insurance framework - the setup for automobile fraud would be slightly different, but the main conclusions would not - suppose a game between a risk neutral principal and risk averse agents. Agent may be of two types: **Truth** and **Dares**. Truths always tell the truth whereas Dares commit insurance fraud if they believe it is in their best interest. The proportion of Dares in the economy is given by  $\xi$ . All agents, Truths and Dares alike, have the same VonNeumann-Morgenstern utility function over final wealth (with  $U'(\cdot) > 0$ ,  $U''(\cdot) < 0$  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. The sequence of the game is presented in Figure 1.

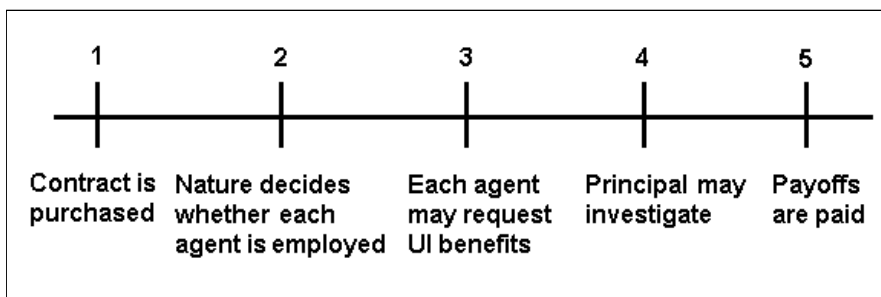


Figure 1: Sequence of play.

In the first stage of the game agents are offered a menu of contracts that specify an unemployment insurance benefit  $\beta$  and a premium  $p$ . I assume that the unemployment insurance contract

is actuarially fair so that the premium ( $p$ ) is exactly equal to the expected benefits paid in case of unemployment plus expenses due to fraud. As a result, the setup lets the principal design the contract so that she makes no profit in equilibrium. Moreover, the agents' utility is maximized.

An agent is unemployed with probability  $\pi < \frac{1}{2}$ . The agent's employment condition is unknown to the principal so that his possible actions are to request unemployment insurance benefits or not. The principal may then investigate the agent at cost  $c$  to acquire this information. If caught committing fraud the agent must incur some penalty. The sunk cost penalty is represented as some fixed disutility  $k$ ,<sup>4</sup> such as prison time or reputational loss. Finally the payoffs are paid and the game ends.

### 3 Optimal Contract when the Type Is 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  $k$ . I present this as my first proposition.<sup>5</sup>

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

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

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<sup>4</sup>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. For a similar treatment of the penalty, see Levitt (1997). I could let the principal collect a small fraction of the penalty as in Picard (1996) and Boyer (2004) without altering my results significantly. The only difference would be that the insurance premium would reflect the part of the penalty paid back to the principal when an investigation reveals that fraud has been committed. As a result, the principal's willingness to investigate increases and the agent's willingness to commit fraud decreases, which ultimately leads to a reduction in the premium. I briefly address this issue in Section 3.2.

<sup>5</sup>All proofs are in the Appendix.

### 3.2 Dares

The Dares' problem is more complicated. The payoffs to the Dares and the principal contingent on all possible actions are displayed in Table 1.

<b>Table 1</b>				
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
<i>Employed</i>	<i>Don't request benefits</i>	<i>Investigate</i>	$U(Y + W - p)$	$p - c$
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	$U(Y + W - p + \beta)$	$p - \beta$
<i>Unemployed</i>	<i>Don't request benefits</i>	<i>Investigate</i>	$U(Y - p)$	$p - c$
<i>Unemployed</i>	<i>Don't request benefits</i>	<i>Don't investigate</i>	$U(Y - p)$	$p$
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.

The principal must specify a price-coverage contract pair that maximizes the Dares' expected utility subject to equilibrium strategy constraints.

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

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

$$\nu = \frac{U(Y + W - p + \beta) - U(Y + W - p)}{U(Y + W - p + \beta) - U(Y + W - p) + k} \quad (2)$$

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 fraud goes undetected, the fair price of this contract is given by

$$p = \pi\beta + (1 - \pi)\beta\eta(1 - \nu) + c\nu[\pi + (1 - \pi)\eta] \quad (3)$$

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

The problem faced by the principal is then

$$\begin{aligned} \max_{p, \beta} EU &= \pi U(Y - p + \beta) + (1 - \pi)(1 - \eta) U(Y + W - p) \\ &\quad + (1 - \pi) \eta [(1 - \nu) U(Y + W - p + \beta) + \nu U(Y + W - p) - \nu k] \end{aligned} \quad (4)$$

subject to (1), (2), (3) and a participation constraint.

Clearly, the probability of fraud ( $\eta$ ) is independent of the premium ( $p$ ). On the other hand, the probability the principal investigates ( $\nu$ ) depends on the benefits and the premium. By designing the optimal contract  $(p, \beta)$ , the principal rationally anticipates its impact on the strategic behavior of the players. Although the parameter  $k$  appears in the function to maximize (4) as well as in constraint (2), Proposition 2 shows that it has no impact in equilibrium on the optimal contract.

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

$$\frac{U' \left( Y - \pi \frac{\beta^2}{\beta - c} + \beta \right)}{\pi U' \left( Y - \pi \frac{\beta^2}{\beta - c} + \beta \right) + (1 - \pi) U' \left( Y + W - \pi \frac{\beta^2}{\beta - c} \right)} = \frac{\beta(\beta - 2c)}{(\beta - c)^2} \quad (5)$$

Similarly to Khalil (1997) and Boyer (2001), three reasons explain the penalty's irrelevance: 1- The principal moves last; 2- The principal is unable to commit to an investigating strategy; and 3- The penalty is sunk.

The first two reasons rely on the fact that the principal chooses her investigation policy so that Dares are indifferent between committing fraud and telling the truth, given they are employed. Because the Dares must be indifferent, their utility must be equal whether they commit fraud or not. If they do not commit fraud, their utility is given by  $U(Y + W - p)$ , which is independent of the penalty. The sunk cost penalty prevents the principal from gaining anything by investigating so that  $k$  does not find itself in the premium function. Using Proposition 2, I am able to state Corollary 1.

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

This corollary follows directly from the proof of Proposition 2. Since the sunk cost penalty has no impact on the shape of the optimal contract (i.e.,  $\beta$  is independent of  $k$ ), and since the only variable in the problem that has an impact on the Dare's probability of fraud is the indemnity payment  $\beta$ , it follows that the sunk cost penalty has no impact on the amount of fraud in the economy.

If some part of the penalty is paid to the principal, however, then that part will have an impact on the optimal contract. Nevertheless, the sunk cost portion would still have no impact. To see why, suppose the agent must pay the principal some monetary amount  $m$  if caught on top of the sunk cost penalty  $k$ . The utility of the agent caught committing fraud is  $U(Y - p + W - m) - k$ , whereas the principal receives a payoff of  $p - c + m$ . Simplifying the overall problem as before yields

$$\max_{p, \beta} EU = \pi U(Y - p + \beta) + (1 - \pi) U(Y + W - p) \quad \text{Subject to } p = \pi \frac{\beta(\beta + m)}{\beta + m - c}$$

Clearly the sunk cost penalty  $k$  still has no impact on the optimal contract.<sup>6</sup>

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 Optimal Contract when Types are Unknown

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. The extensive form of the game is given in Figure 2 below. In this game  $B$  represents an agent who requests unemployment insurance benefits,  $0$ , an agent who does not,  $I$ , the principal who investigates the agent, and  $N$ , the principal who does not.

Let the principal maximize the expected utility of the Truths. Denote by a subscript  $T$  the allocation of the Truths, and by  $D$ , the allocation of the Dares. If it exists, the optimal separating contract maximizes the following problem:

$$\max_{\beta_T, p_T, \beta_D, p_D, \eta, \nu} EU_T = \pi U(Y - p_T + \beta_T) + (1 - \pi) U(Y + W - p_T) \quad (6)$$

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<sup>6</sup>Karpoff and Lott (1993), Waldfogel (1994) and Grogger (1995) show that the reputational loss (by definition a purely sunk loss) associated with a criminal conviction far outweighs any direct penalty inflicted on criminal elements so that the sunk cost component of the penalty appears much larger than any fine paid to the principal. In the case of Waldfogel, a fraud conviction reduces the offender's future income by as much as 30%, even though the direct fine is much smaller. In the case of Karpoff and Lott, a loss of reputation for a corporation is associated with an abnormal stock return between -1.34 % and -5.05 % depending on the type of fraud; this represents more than ten times the sum of any fine, penalty or court-imposed costs.

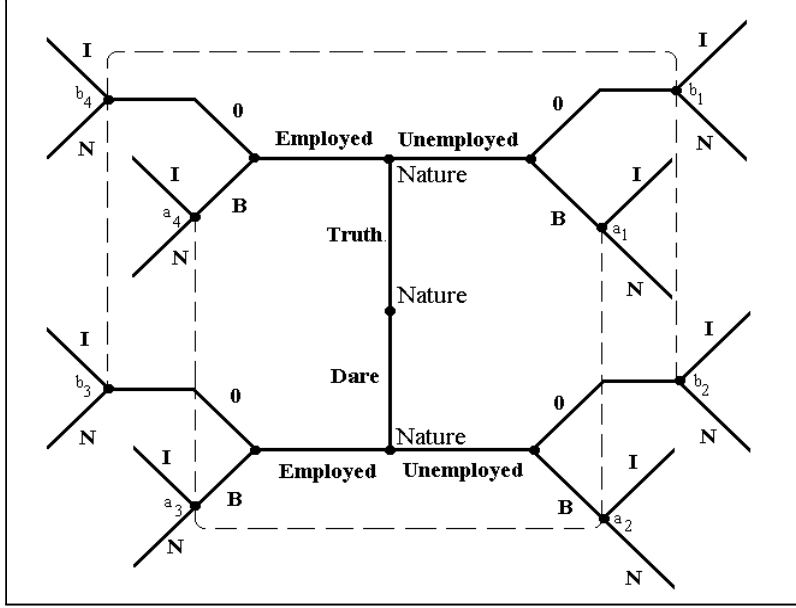


Figure 2: Extensive form of the game where agents know their type (Truth or Dare) and whether they are employed or not. The dash lines represent the principal's information sets.

subject to

$$\begin{aligned} \pi U(Y - p_D + \beta_D) + (1 - \pi)(1 - \eta)U(Y + W - p_D) \\ + (1 - \pi)\eta(1 - \nu)U(Y + W - p_D + \beta_D) \\ + (1 - \pi)\eta\nu[U(Y + W - p_D) - k] \end{aligned} \geq \pi U(Y) + (1 - \pi)U(Y + W) \quad (7)$$

$$\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \geq \pi U(Y) + (1 - \pi)U(Y + W) \quad (8)$$

$$\begin{aligned} \pi U(Y - p_D + \beta_D) + (1 - \pi)(1 - \eta)U(Y + W - p_D) \\ + (1 - \pi)\eta(1 - \nu)U(Y + W - p_D + \beta_D) \\ + (1 - \pi)\eta\nu[U(Y + W - p_D) - k] \end{aligned} \geq \begin{aligned} \pi U(Y - p_T + \beta_T) \\ + (1 - \pi)U(Y + W - p_T + \beta_T) \end{aligned} \quad (9)$$

$$\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \geq \pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D) \quad (10)$$

$$p_T = \pi\beta_T \quad (11)$$

$$p_D = \pi\beta_D + (1 - \pi)\beta_D\eta(1 - \nu) + c\nu(\pi + (1 - \pi)\eta) \quad (12)$$

$$\eta, \nu \in [0, 1] \quad (13)$$

Equations (7) and (8) are the participation constraints of each type of agent. Equations (9) and (10) are the incentive compatibility constraints of each type of agent. Equations (11) and (12) are the principal's participation constraints (zero-profit constraints) associated with the Truths' and

the Dares' contract respectively. Finally, (13) are the boundary conditions on the probability of committing fraud 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 fraud, and if the principal is bound to offer a break-even contract to each type of agent, no separating contract exists.*

Whatever the proportion of Dares, the only contract that will exist in equilibrium is the pooling contract. This means that  $p_T = p_D = p$  and  $\beta_T = \beta_D = \beta$ . Thus the optimal pooling contract solves

$$p = \pi\beta + \xi(1 - \pi)\beta\eta(1 - \nu) + c\xi\nu(\pi + (1 - \pi)\eta) \quad (14)$$

where  $\xi$  is the proportion of Dares in the economy.

Three contracts are then possible in this situation, depending on the behavior of the players in the last stages of the game. In the first case,  $\eta < 1$  and  $\nu > 0$ , so that an employed Dare randomizes between committing fraud and not committing fraud and, given that an agent has requested benefits, the principal investigates only with some probability. In the second case,  $\eta = 1$  and  $\nu > 0$ , so that a Dare always requests benefits, whereas the principal still randomizes between investigating and not investigating. In the last case,  $\eta = 1$  and  $\nu = 0$ , a Dare always requests benefits and the principal never investigates.<sup>7</sup> I derive the optimal contract for the different situations in the next proposition.

**Proposition 3 a)** *If  $\eta < 1$  and  $\nu > 0$ , which occurs only if the proportion of Dares is larger than  $\bar{\xi} = \frac{\pi}{1 - \pi} \left( \frac{c}{\beta_{\eta\nu} - c} \right)$ , 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.*

**b)** *If  $\eta = 1$  and  $\nu > 0$ , then*

$$\nu_{0\nu}^* = 1 - \frac{\pi}{\xi} \frac{U'(Y - p_{0\nu}^* + \beta_{0\nu}^*) - U'(Y + W - p_{0\nu}^*)}{\pi U'(Y - p_{0\nu}^* + \beta_{0\nu}^*) + (1 - \pi)U'(Y + W - p_{0\nu}^*)} \quad (15)$$

$$p_{0\nu}^* = c \left( \frac{[\pi + \xi(1 - \pi)]^2}{\xi(1 - \pi)} \right) = [\pi + \xi(1 - \pi)]\beta \quad (16)$$

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<sup>7</sup>The case where the principal never investigates and Dares randomize is not a sustainable Nash equilibrium; Dares always have an incentive to commit fraud if the principal never audits.

$$\beta_{0\nu}^* = c \left[ \frac{\pi + \xi(1 - \pi)}{\xi(1 - \pi)} \right] \quad (17)$$

c) If  $\eta = 1$  and  $\nu = 0$ , then

$$p_{00}^* = \pi\beta_{00}^* \left[ 1 + \xi \left( \frac{1 - \pi}{\pi} \right) \right] \quad (18)$$

and  $\beta_{00}^*$  solves

$$\frac{U'(Y - p_{00}^* + \beta_{00}^*)}{\pi U'(Y - p_{00}^* + \beta_{00}^*) + (1 - \pi) U'(Y + W - p_{00}^*)} = 1 + \xi \left( \frac{1 - \pi}{\pi} \right) \quad (19)$$

Note that for the three types of contracts, the only endogenous variable is the benefit ( $\beta$ ). When  $\eta < 1$  and  $\nu > 0$ , which occurs only when  $\xi > \xi^*$ , no information on the exact proportion of Dares may be gathered from the shape of the equilibrium contract. Irrespective of the proportion of Dares between  $\xi^*$  and 1, the contract is the same as the one presented in Proposition 2.

Interestingly, when  $\eta = 1$  and  $\nu > 0$ , the optimal contract does not depend on the principal's investigating strategy. The reason is 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  $\beta_{0\nu}^*$ , I find  $p_{0\nu}^*$ , and then  $\nu_{0\nu}^*$ .

In the case of  $\eta = 1$  and  $\nu = 0$ , again the only choice variable is  $\beta_{00}^*$ , since  $p_{00}^*$  is obtained directly from  $\beta_{00}^*$ . The functions that determine  $\beta_{00}^*$  and  $p_{00}^*$  (equations 19 and 18) are the same as the one used to obtain the optimal insurance contract when a proportional loading factor equal to  $\xi \frac{1 - \pi}{\pi}$  exists. The first best insurance contract ( $\beta_{00}^* = W$ ) occurs when  $\xi \rightarrow 0$ .

Theorem 2 determines which contract applies when.

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

The intuition behind this contract structure is that when there are only a few Dares in the economy, enforcing the law becomes more costly than letting fraud go undetected. To see why, consider the case of only one Dare in a large economy of  $N$  individuals. The expected total cost of never investigating is  $(1 - \pi)\beta$ . On the other hand, the expected total cost of investigating with

probability  $\nu$  is  $(1 - \pi)(1 - \nu)\beta + N\pi\nu c + (1 - \pi)\nu c$ .<sup>8</sup> Not investigating is then better when

$$(1 - \pi)\beta \leq (1 - \pi)(1 - \nu)\beta + N\pi\nu c + (1 - \pi)\nu c \quad (20)$$

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 fraud investigation becomes profitable. Indeed as the number of agents who potentially commit fraud 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  $\nu$  is then optimal if and only if

$$D(1 - \pi)\beta - D(1 - \pi)(1 - \nu)\beta - N\pi\nu c - D(1 - \pi)\nu c \leq 0 \quad (21)$$

which holds when  $\beta \leq \left(\frac{N}{D}\frac{\pi}{1-\pi} + 1\right)c$ . As the number of Dares ( $D$ ) increases, this inequality is less likely to hold.

Figures 3A and 3B present (Figure 3B focuses on the "interesting" part of Figure 3A) the expected utility received by the Truths under each contract.<sup>9</sup> We see in both figures that the contract where  $\eta = 1$  and  $\nu = 0$  always dominates the contract where  $\eta = 1$  and  $\nu > 0$ . The contract where  $\eta = 1$  and  $\nu = 0$  is thus preferred to the contract where  $\eta = 1$  and  $\nu > 0$ .

[INSERT FIGURE 3A HERE]

[INSERT FIGURE 3B HERE]

Figure 3A also shows that for lower values of  $\xi$  the expected utility of Truths is highest when  $\eta = 1$  and  $\nu = 0$ . For larger  $\xi$ , the Truths' expected utility is highest with  $\eta < 1$  and  $\nu > 0$ . The two contracts yield the same expected utility when  $\xi = \xi^*$  (the expected utility functions are tangent at that point). Interestingly, we see that  $\xi^* > \bar{\xi}$ , the minimum proportion of Dares so that  $\eta < 1$  and  $\nu > 0$  can be an equilibrium.

Figure 4 plots the optimal combination of contracts where we see that, although the Truths' expected utility decreases as the proportion of Dares increases until  $\xi = \xi^*$ , for all  $\xi > \xi^*$  a higher proportion of Dares does not alter the expected utility of the Truths. We can thus separate our discussion of the optimal contract as a function of the proportion of Dares.

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<sup>8</sup>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.

<sup>9</sup>I 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.

[INSERT FIGURE 4 HERE]

On the first part of the graph, when  $\xi < \xi^*$  so that the principal never investigates, the shape of the optimal contract is similar to the optimal contract when a proportional loading factor on the premium exists. As the loading factor increases (as  $\xi$  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 graph ( $\xi > \xi^*$ ), the expected utility of agents is constant because Dares adjust their behavior to the proportion of Dares. As  $\xi$  increases beyond  $\xi^*$  (which lowers expected utility), the probability that any one Dare commits fraud decreases (which increases expected utility). In equilibrium, the two effects cancel out as shown in Proposition 3.

In Figure 5, I present the optimal benefit and the unconditional probability of fraud as a function of the proportion of Dares. Figure 5 shows that the optimal benefit decreases as  $\xi$  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 ( $\beta > W$ ).<sup>10</sup> 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  $\xi > \xi^*$ . When  $\xi < \xi^*$ , the principal never needs to signal since she never investigates so that  $\beta < W$ .

[INSERT FIGURE 5 HERE]

Figure 6 presents any Dare's probability of committing fraud ( $\eta$ ), conditional on being a Dare, and the probability the principal investigates ( $\nu$ ). Note the discreet jump in both measures when  $\xi = \xi^*$ . In the case of fraud, the probability drops suddenly and keeps decreasing as the proportion

<sup>10</sup>This is easily shown theoretically using Proposition 2 since the contract is independent of  $\xi$  when  $\xi > \xi^*$ . The first order condition entails

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

Letting  $\beta = W$  yields

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

This is obviously positive since  $c^2 > 0$ . Thus, the solution to the maximization problem must be such that  $\beta^* > W$ .

of Dares increases. The principal's investigation probability increases suddenly and then remains constant for all  $\xi > \xi^*$ .

[INSERT FIGURE 6 HERE]

The reason for this result is that the investigating probability is independent of the *exact* proportion of Dares in the sense that either the principal never investigates (when  $\xi < \xi^*$ ) or she investigates with probability  $\nu^*$  that is independent of  $\xi$  (see equation 2). As a result, there are only two possible probabilities of auditing. These are represented by the two horizontal lines. In terms of the conditional of committing fraud, when  $\xi < \xi^*$ , Dares always commit fraud so the conditional probability is 1. When the proportion of Dares is greater than  $\xi^*$ , the probability that any Dare commits fraud, given by  $\eta = \left(\frac{\pi}{1-\pi}\right) \left(\frac{c}{\beta-c}\right) \frac{1}{\xi}$  decreases even though the unconditional probability  $\eta_u$  remain constant since  $\eta_u = \eta\xi$ . As the proportion of Dares is large, each one expects to be investigated with probability  $\nu$ . Each also must commit fraud with probability  $\eta$  that decreases with the proportion of Dares in the economy in order for the principal to be indifferent between auditing his report or not.

## 5 Fraud Prevention

So far I have shown in the paper 1- that it is impossible to separate the two types of agents, and 2- that the optimal contract independent of the proportion of Dares as long as their proportion is high enough. What is left to address is the impact of fraud prevention.

### 5.1 Benefits of prevention

Suppose the government's prevention technology allows to turn Dares into Truths. In other words, the technology allows to alter the distribution of types. Fraud prevention is achieved by spending some amount  $X \geq 0$  such that  $\xi'_X < 0$  and  $\xi''_{XX} > 0$ . This amount  $X$  must come from taxes levied on the general population. Suppose that investment in prevention is financed using a poll tax so that an amount  $x$  is collected from each agent in the economy (i.e.,  $X = Nx$ ).

To judge whether prevention is warranted we need to examine its impact on both parts of the contract displayed in Figure 4. This yields Proposition 4.

**Proposition 4** *When  $\eta < 1$  and  $\nu > 0$ , the amount of fraud is independent of  $\xi$  so that, at the margin, fraud prevention has no impact on crime. When  $\eta = 1$  and  $\nu = 0$ , the amount of fraud increases with  $\xi$  so that prevention reduces fraud as it reduces  $\xi$ .*

This proposition implies that if the moral fiber of the population is weak (i.e., the proportion of Dares is greater than  $\xi^*$ ) then prevention becomes a waste of scarce resources since fraud prevention is useless. On the other hand, when  $\xi < \xi^*$ , Dares always cheat so that reducing their number will reduce fraud in the economy. The question then becomes when is investment in prevention warranted?

Let us examine what happens when  $\xi \leq \xi^*$ . The principal's problem is then

$$\begin{aligned} \max_{\beta, x} EU &= \pi U(Y + (1 - \pi)\beta - \xi(X)(1 - \pi)\beta - x) \\ &\quad + (1 - \pi)U(Y + W - \pi\beta - \xi(X)(1 - \pi)\beta - x) \end{aligned} \quad (22)$$

The first order conditions are

$$\begin{aligned} \frac{\partial EU}{\partial \beta} &= 0 = \pi U'(Y + (1 - \pi)\beta - \xi(X)(1 - \pi)\beta - x) [1 - \pi - \xi(X)(1 - \pi)] \\ &\quad - (1 - \pi)U'(Y + W - \pi\beta - \xi(X)(1 - \pi)\beta - x) [\pi + \xi(X)(1 - \pi)] \end{aligned} \quad (23)$$

$$\begin{aligned} \frac{\partial EU}{\partial x} &= 0 = -\pi U'(Y + (1 - \pi)\beta - \xi(X)(1 - \pi)\beta - x) [1 + \beta\xi'(X)N(1 - \pi)] \\ &\quad - (1 - \pi)U'(Y + W - \pi\beta - \xi(X)(1 - \pi)\beta - x) [1 + \beta\xi'(X)N(1 - \pi)] \end{aligned} \quad (24)$$

The solution to this problem is

$$\frac{U'(Y - \pi\beta - \beta\xi(X)(1 - \pi) + \beta - x)}{\left[ \begin{array}{l} \pi U'(Y - \pi\beta - \beta\xi(X)(1 - \pi) + \beta - x) \\ + (1 - \pi)U'(Y + W - \pi\beta - \beta\xi(X)(1 - \pi) - x) \end{array} \right]} = 1 + \xi(X) \left( \frac{1 - \pi}{\pi} \right) \quad (25)$$

and

$$-\xi'(X) = \frac{1}{(1 - \pi)N\beta} \quad (26)$$

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, 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 prevention by turning Dares into Truths when fraud is more costly to society (higher  $\beta$  means that Dares receive more when they commit fraud). As for  $\frac{\partial X}{\partial \pi} < 0$ , since more agents need the benefits to compensate for a real loss, there is less need to change Dares into Truths since fraud is less likely to be committed.

## 5.2 Cost of prevention

Although the optimal level of prevention is positive, one must make sure that the resulting expected utility is greater than in the case where nothing is done and the proportion of Dares remains greater than  $\xi^*$ . Figure 7 illustrates what is happening. For prevention to be effective, the proportion of Dares has to be on the downward sloping portion of expected utility curve.<sup>11</sup> This is characterized by a translation of the entire utility frontier for all  $\xi < \xi^*$ . Fraud prevention thus has two conflicting results on an agent's utility. First, his utility increases because the proportion of Dares decreases (if  $\xi(X^*) < \xi^*$ , otherwise an agent's expected utility is invariant). Second, his utility decreases because he must pay  $x$  dollars in taxes.

[INSERT FIGURE 7 HERE]

Fraud prevention could therefore be unwarranted if the reduction in fraud is more than upset by an increase in taxes. It then follows that investment in fraud prevention is warranted if and only if

$$\left[ \begin{array}{l} \pi U(Y + (1 - \pi)\beta_x^* - \xi(X)(1 - \pi)\beta_x^* - x) \\ +(1 - \pi)U(Y + W - \pi\beta_x^* - \xi(X)(1 - \pi)\beta_x^* - x) \end{array} \right] > \left[ \begin{array}{l} \pi U(Y - p_{\eta\nu}^* + \beta_{\eta\nu}^*) \\ +(1 - \pi)U(Y + W - p_{\eta\nu}^*) \end{array} \right] \quad (27)$$

Thus, depending on the efficiency of the fraud prevention technology and on the initial proportion of Dares, investment in prevention is not necessarily advantageous. Obviously, the more efficient the technology, the greater the incentive to invest in prevention. Also, we see that the greater the proportion of Dares, the smaller are the incentives to invest in prevention.

## 5.3 Can prevention be worthless, or even worse?

When there are many Dares in the economy, investment in prevention is not useful because, as the number of Dares declines, the incentives of the remaining Dares to commit fraud increases so that, in equilibrium, the two effects offset each other perfectly. In other words, conditional on being a Dare the probability of fraud is  $\eta = \left(\frac{\pi}{1-\pi}\right) \left(\frac{c}{\beta(X)-c}\right) \frac{1}{\xi(X)}$ . As  $\xi(X)$  decreases,  $\eta$  increases so that the unconditional probability of fraud is  $\eta_u = \left(\frac{\pi}{1-\pi}\right) \left(\frac{c}{\beta(X)-c}\right)$ , which is independent of  $\xi(X)$ . Thus investing in prevention when  $\xi \gg \xi^*$  only reduces the agents' expected utility.

<sup>11</sup>For all  $\xi > \xi^*$ , there is no point in investing in prevention. Therefore, at the optimum, only the expected utility frontier for value  $\xi < \xi^*$  will ever move downwards.

Paradoxically, investment in prevention can also increase fraud. To see why, suppose that the proportion of Dares remains greater than  $\xi^*$  after an investment in prevention. Because the unconditional probability of fraud is  $\eta_u = \eta\xi(X) = \left(\frac{\pi}{1-\pi}\right) \left(\frac{c}{\beta(X)-c}\right)$ , fraud will increase in the economy if and only if  $\frac{\partial\eta}{\partial X} = \frac{\partial\eta}{\partial\beta} \frac{\partial\beta}{\partial X} > 0$ . Because  $\frac{\partial\eta}{\partial\beta} < 0$ , fraud increases if and only if  $\frac{d\beta}{dX} < 0$ . Using the envelope theorem, I can show that  $\frac{d\beta}{dX} < 0$  if the agent's utility function does not display increasing absolute risk aversion.<sup>12</sup>

## 6 Dynamic Considerations

I assumed in this paper that the penalty is fixed and equal to some disutility amount  $k$ . Alternatively, I can also suppose that agents are infinitely lived, but once they are found to have committed fraud, their type becomes known so that they are banned completely from the market (autarchy).

For example, following Waldfogel (1994), I could assume that an agent found guilty of fraud is banned forever from participating in the market because, perhaps, his reputation is tarnished. As a result an agent found to have committed fraud will find himself in autarchy so that his expected utility is  $EU^A = \pi U(Y) + (1-\pi)U(Y+W)$  in every period. Given that the the Dare's expected utility is  $EU^* > EU^A$  if he participates in the market, being excluded permanently results in a loss of utility equal to  $EU^* - EU^A$  at each period forever. Using a discount rate of  $\delta$ , the sunk cost penalty may be set to  $k^* = k + \frac{EU^* - EU^A}{\delta} > 0$ .

Because the number of unknown Dares is reduced when some are caught committing fraud, their proportion in the economy is lowered. This means that the proportion of unknown Dares ultimately reaches  $\xi^*$ , where it remains forever as investigation never occurs again. As a result, no more Dare is found to have committed a crime afterwards, since their proportion remains equal to  $\xi^*$ .

## 7 Conclusion

My paper contributes to the crime and punishment debate by looking at the impact of prevention and punishment in an insurance fraud context. More to the point, I developed a theoretical approach

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<sup>12</sup>Rewriting the first order condition as

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

it can be shown that  $\frac{\partial\Omega}{\partial\beta} < 0$  and that  $\frac{\partial\Omega}{\partial X} > 0$ . Thus  $\frac{d\beta}{dX} > 0$ , which leads to  $\frac{\partial\eta}{\partial X} > 0$ .

in which stiffer penalties and increased prevention could have no impact on the amount of fraud when the proportion of criminal elements in society is too high. The principal-agent model I presented introduced agents that could be of two possible privately-known types that differ only with respect to the propensity to commit fraud: Truths never do whereas Dares have no moral objection to it.

The main results of the paper are four-fold. First, no contract allows to separate Truths from Dares. Second, if the proportion of Dares is large enough, then the pooling contract is independent of their exact proportion. Third, if the proportion of Dares is large enough, then the amount of fraud and the number of agents found to have committed fraud is independent of their exact proportion. Finally, investment in prevention can be useless if the proportion of Dares is large enough so that investing in prevention becomes a waste of resources. This last result holds when the proportion of Dares is large. When their proportion is small, investing in prevention reduces fraud.

Fraud is an important part of the economy, if not the underground economy. Karpoff and Lott (1993) measure the cost of fraud in different circumstances and shows that in the financial market, the only type of fraud that does not seem to have any impact on a firm's value is regulatory violations. One possible explanation is that regulatory violations may be viewed as errors or mistakes so that they are covered under directors' and officers' insurance policies (see Core, 1997, and Gutiérrez, 2004). Interestingly, my model predicts exactly that prevention and prison time (i.e., sunk punishments) could have no incidence on fraud whatsoever.

My model can also be viewed as one where a manager reports positively false accounting figures to the board to increase his year-end bonus. 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.

Two aspects I did not approach is whether there are any political considerations to law enforcement and the implications of moving from a one-period game to a multi-period game. In the first case, 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. In the second case, Cooper and Hayes (1987) show that insurers faced with adverse selection problems over many periods will design the initial period's insurance contract in order to increase their knowledge of an agent's type in the next period. In my setting, this would mean that in earlier periods the proportion of unknown Dares is greater, and that this proportion is reduced as the game goes on. As a result, for a given cohort of insured agents, fraud and the cost of the contract should decrease over time on average.

Similarly, I did not study the optimal way to finance prevention. My model only uses a poll tax to finance prevention, which may be optimal in many settings, but it may not be when the economy is plagued with insurance fraud as shown in Boyer (2000). The poll tax has the advantage of making the analysis easier, but it may not represent reality.

The futility of fraud prevention depends on there being relatively few honest-to-the-core agents in the economy and on a prevention technology that is costly to implement. Nonetheless, as the title of the paper emphasizes, resistance to fraud is futile and wasteful when the proportion of agents that have a low propensity to tell the truth is high.

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## 9 Appendix: Proofs.

### 9.1 Proof of Proposition 1

The maximization problem for the Truth is

$$\max_{p, \beta} EU = \pi U(Y - p + \beta) + (1 - \pi)U(Y + W - p) \quad (28)$$

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

### 9.2 Proof of Proposition 2

Substituting equations (1) and (2) into (3) and (4) yields

$$\max_{p, \beta} EU = \pi U(Y - p + \beta) + (1 - \pi)U(Y + W - p) \quad \text{Subject to } p = \pi \frac{\beta^2}{\beta - c} \quad (29)$$

As in Proposition 1, we see that the penalty is irrelevant. Finding the first order condition and rearranging the terms completes the proof.

### 9.3 Proof of Corollary 1

From (1) a Dare commits a crime with probability  $\eta = f(\beta, \pi, c)$ . The impact of  $k$  on  $\eta$  is then given by  $\frac{\partial \eta}{\partial k} = \frac{\partial f}{\partial \beta} \frac{\partial \beta}{\partial k}$  since  $\pi$  and  $c$  are parameters. From proposition 2 we know that  $\beta$  is independent of  $k$ . It follows that  $\eta$  is independent of  $k$ .

### 9.4 Proof of Theorem 1

The proof has four parts, each corresponding to the four potential Nash equilibrium situations: 1-  $\eta < 1$  and  $\nu > 0$ ; 2-  $\eta = 1$  and  $\nu = 0$ ; 3-  $\eta = 1$  and  $\nu > 0$ ; 4-  $\eta < 1$  and  $\nu = 0$ .

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

$$\eta = \left( \frac{\pi}{1 - \pi} \right) \left( \frac{c}{\beta_D - c} \right) \quad (30)$$

and

$$\nu = \frac{U(Y + W - p_D + \beta_D) - U(Y + W - p_D)}{U(Y + W - p_D + \beta_D) - U(Y + W - p_D) + k} \quad (31)$$

Substituting (31) into (9) yields

$$\pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D) \geq \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T) \quad (32)$$

Note that the left hand side of (32) is equal to the right hand side of (10) so that

$$\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \geq \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T) \quad (33)$$

This occurs only if  $\beta_T = \beta_D = 0$ . Thus (9) and (10) cannot hold at the same time, which means that no separating contracts exists when  $\eta < 1$  and  $\nu > 0$ .

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

$$\begin{aligned} \max_{\beta_T, p_T, \beta_D, p_D} EU_T &= \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \\ &+ \lambda_{00} \left[ \begin{array}{c} \pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D + \beta_D) \\ -\pi U(Y) - (1 - \pi)U(Y + W) \end{array} \right] \\ &+ \lambda_{01} \left[ \begin{array}{c} \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \\ -\pi U(Y) - (1 - \pi)U(Y + W) \end{array} \right] \\ &+ \lambda_1 \left[ \begin{array}{c} \pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D + \beta_D) \\ -\pi U(Y - p_T + \beta_T) - (1 - \pi)U(Y + W - p_T + \beta_T) \end{array} \right] \\ &+ \lambda_2 \left[ \begin{array}{c} \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \\ -\pi U(Y - p_D + \beta_D) - (1 - \pi)U(Y + W - p_D) \end{array} \right] \\ &+ \lambda_3 [p_T - \pi\beta_T] + \lambda_4 [p_D - \beta_D] \end{aligned} \quad (34)$$

The first order conditions of the problem are

$$\begin{aligned} \frac{\partial EU_T}{\partial \beta_T} &= 0 = \pi U'(Y - p_T + \beta_T) (1 + \lambda_2 + \lambda_{01}) - \lambda_3 \pi \\ &- \lambda_1 [\pi U'(Y - p_T + \beta_T) + (1 - \pi)U'(Y + W - p_T + \beta_T)] \end{aligned} \quad (35)$$

$$\begin{aligned} \frac{\partial EU_T}{\partial p_T} &= 0 = -[\pi U'(Y - p_T + \beta_T) + (1 - \pi)U'(Y + W - p_T)] (1 + \lambda_2 + \lambda_{01}) \\ &+ \lambda_1 [\pi U'(Y - p_T + \beta_T) + (1 - \pi)U'(Y + W - p_T + \beta_T)] + \lambda_3 \end{aligned} \quad (36)$$

$$\begin{aligned} \frac{\partial EU_T}{\partial \beta_D} &= 0 = -\pi U'(Y - p_D + \beta_D) \lambda_2 - \lambda_4 \\ &+ (\lambda_1 + \lambda_{00}) [\pi U'(Y - p_D + \beta_D) + (1 - \pi)U'(Y + W - p_D + \beta_D)] \end{aligned} \quad (37)$$

$$\begin{aligned} \frac{\partial EU_T}{\partial p_D} &= 0 = [\pi U'(Y - p_D + \beta_D) + (1 - \pi)U'(Y + W - p_D)] \lambda_2 + \lambda_4 \\ &- (\lambda_1 + \lambda_{00}) [\pi U'(Y - p_D + \beta_D) + (1 - \pi)U'(Y + W - p_D + \beta_D)] \end{aligned} \quad (38)$$

to which we add the complementary slackness conditions

$$\lambda_{00} [\pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D + \beta_D) - \pi U(Y) - (1 - \pi)U(Y + W)] = 0 \quad (39)$$

$$\lambda_{01} [\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) - \pi U(Y) - (1 - \pi)U(Y + W)] = 0 \quad (40)$$

$$\lambda_1 \left[ \begin{array}{l} \pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D + \beta_D) \\ -\pi U(Y - p_T + \beta_T) - (1 - \pi)U(Y + W - p_T + \beta_T) \end{array} \right] = 0 \quad (41)$$

$$\lambda_2 \left[ \begin{array}{l} \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \\ -\pi U(Y - p_D + \beta_D) - (1 - \pi)U(Y + W - p_D) \end{array} \right] = 0 \quad (42)$$

Adding equations 35 and 36, and equations 37 and 38, yields

$$\frac{\partial EU_T}{\partial \beta_T} + \frac{\partial EU_T}{\partial p_T} = -(1 + \lambda_2 + \lambda_{01})(1 - \pi)U'(Y + W - p_T) + \lambda_3(1 - \pi) = 0 \quad (43)$$

and

$$\frac{\partial EU_T}{\partial \beta_D} + \frac{\partial EU_T}{\partial p_D} = \lambda_2(1 - \pi)U'(Y + W - p_D) = 0 \quad (44)$$

This means that  $\lambda_2 = 0$ , and thus

$$\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \geq \pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D) \quad (45)$$

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

$$\pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D + \beta_D) = \pi U(Y) + (1 - \pi)U(Y + W) \quad (46)$$

There is therefore no loss in generality to let  $\beta_D = 0$ . From 41 we know that

$$\pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D + \beta_D) \geq \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T) \quad (47)$$

Substituting 46 into 47 yields that

$$\pi U(Y) + (1 - \pi)U(Y + W) \geq \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T) \quad (48)$$

which is not possible unless  $\beta_T = 0$ . If  $\beta_T = 0$  and  $\beta_D = 0$ , then the contract is not separating when  $\eta = 1$  and  $\nu = 0$ .

**PART 3.** The third possibility is that  $\nu > 0$ , and  $\eta = 1$ . The Lagrangian is

$$\begin{aligned}
\max_{\beta_T, p_T, \beta_D, p_D, \nu} EU_T &= \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \\
&+ \lambda_{00} \left[ \begin{aligned} &\pi U(Y - p_D + \beta_D) + (1 - \pi)(1 - \nu)U'(Y + W - p_D + \beta_D) \\ &+ (1 - \pi)\nu[U(Y + W - p_D) - k] - \pi U(Y) - (1 - \pi)U(Y + W) \end{aligned} \right] \\
&+ \lambda_{01} \left[ \begin{aligned} &\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \\ &- \pi U(Y) - (1 - \pi)U(Y + W) \end{aligned} \right] \\
&+ \lambda_1 \left[ \begin{aligned} &\pi U(Y - p_D + \beta_D) + (1 - \pi)(1 - \nu)U(Y + W - p_D + \beta_D) \\ &+ (1 - \pi)\nu[U(Y + W - p_D) - k] \\ &- \pi U(Y - p_T + \beta_T) - (1 - \pi)U(Y + W - p_T + \beta_T) \end{aligned} \right] \\
&+ \lambda_2 \left[ \begin{aligned} &\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \\ &- \pi U(Y - p_D + \beta_D) - (1 - \pi)U(Y + W - p_D) \end{aligned} \right] \\
&+ \lambda_3 [p_T - \pi\beta_T] + \lambda_4 [p_D - \pi\beta_D - (1 - \pi)\beta_D(1 - \nu) - c\nu] + \lambda_5\nu
\end{aligned} \tag{49}$$

The first order conditions are

$$\begin{aligned}
\frac{\partial EU_T}{\partial \beta_T} &= 0 = \pi U'(Y - p_T + \beta_T)(1 + \lambda_2 + \lambda_{01}) - \lambda_3\pi \\
&- \lambda_1 [\pi U'(Y - p_T + \beta_T) + (1 - \pi)U'(Y + W - p_T + \beta_T)]
\end{aligned} \tag{50}$$

$$\begin{aligned}
\frac{\partial EU_T}{\partial p_T} &= 0 = -[\pi U'(Y - p_T + \beta_T) + (1 - \pi)U'(Y + W - p_T)](1 + \lambda_2 + \lambda_{01}) \\
&+ \lambda_1 [\pi U'(Y - p_T + \beta_T) + (1 - \pi)U'(Y + W - p_T + \beta_T)] + \lambda_3
\end{aligned} \tag{51}$$

$$\begin{aligned}
\frac{\partial EU_T}{\partial \beta_D} &= 0 = -\pi U'(Y - p_D + \beta_D)\lambda_2 - \lambda_4[\pi + (1 - \pi)(1 - \nu)] \\
&+ (\lambda_1 + \lambda_{00})[\pi U'(Y - p_D + \beta_D) + (1 - \pi)(1 - \nu)U'(Y + W - p_D + \beta_D)]
\end{aligned} \tag{52}$$

$$\begin{aligned}
\frac{\partial EU_T}{\partial p_D} &= 0 = [\pi U'(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D)]\lambda_2 + \lambda_4 \\
&- (\lambda_1 + \lambda_{00}) \left[ \begin{aligned} &\pi U'(Y - p_D + \beta_D) + (1 - \pi)(1 - \nu)U'(Y + W - p_D + \beta_D) \\ &+ (1 - \pi)\nu U'(Y + W - p_D) \end{aligned} \right]
\end{aligned} \tag{53}$$

$$\begin{aligned}
\frac{\partial EU_T}{\partial \nu} &= 0 = \lambda_4(1 - \pi)\beta_D + \lambda_5 \\
&+ (\lambda_1 + \lambda_{00})(1 - \pi)[U(Y - p_D + W) - k - U(Y + W - p_D + \beta_D)]
\end{aligned} \tag{54}$$

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

$$\frac{\partial EU_T}{\partial \beta_T} + \frac{\partial EU_T}{\partial p_T} = (1 - \pi)\lambda_3 - (1 - \pi)U'(Y + W - p_T)(1 + \lambda_2 + \lambda_{01}) = 0 \tag{55}$$

$$\frac{\partial EU_T}{\partial \beta_D} + \frac{\partial EU_T}{\partial p_D} = 0 = -\lambda_4 [1 - \pi - (1 - \pi)(1 - \nu)] + (1 - \pi)U(Y + W - p_D) \lambda_2 \quad (56)$$

$$- (\lambda_1 + \lambda_{00}) [(1 - \pi) \nu U'(Y + W - p_D)]$$

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

$$\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) = \pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D) \quad (57)$$

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

$$\begin{aligned} & \pi U(Y - p_D + \beta_D) \\ & + (1 - \pi)(1 - \nu)U(Y + W - p_D + \beta_D) \geq \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T) \quad (58) \\ & + (1 - \pi)\nu [U(Y + W - p_D) - k] \end{aligned}$$

Clearly,

$$\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T) > \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \quad (59)$$

Using 57 we have that

$$\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T) > \pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D) \quad (60)$$

Substituting in 58 yields

$$\begin{aligned} & \pi U(Y - p_D + \beta_D) \\ & + (1 - \pi)(1 - \nu)U(Y + W - p_D + \beta_D) > \pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D) \quad (61) \\ & + (1 - \pi)\nu [U(Y + W - p_D) - k] \end{aligned}$$

This means that

$$\begin{aligned} & \pi U(Y - p_D + \beta_D) + (1 - \pi)(1 - \nu)U(Y + W - p_D + \beta_D) \\ & + (1 - \pi)\nu [U(Y + W - p_D) - k] > \pi U(Y) + (1 - \pi)U(Y + W) \quad (62) \end{aligned}$$

since

$$U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D) \geq \pi U(Y) + (1 - \pi)U(Y + W) \quad (63)$$

Therefore,  $\lambda_{00} = 0$ . Since  $\lambda_1 + \lambda_{00} > 0$ , we must have  $\lambda_1 > 0$  so that

$$\begin{aligned} & \pi U(Y - p_D + \beta_D) \\ & + (1 - \pi)(1 - \nu)U(Y + W - p_D + \beta_D) = \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T) \quad (64) \\ & + (1 - \pi)\nu [U(Y + W - p_D) - k] \end{aligned}$$

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 when  $\nu > 0$ , and  $\eta = 1$ .

**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  $\eta = 1$ . Part 3 of the proof shows that such a contract is not separating.

### 9.5 Proof of Proposition 3

Again, the proof is done by parts, each one corresponding to one of the three Nash equilibrium situations: 1-  $\eta < 1$  and  $\nu > 0$ ; 2-  $\eta = 1$  and  $\nu = 0$ ; and 3-  $\eta = 1$  and  $\nu > 0$ .<sup>13</sup>

**PART 1.** Suppose  $\eta < 1$  and  $\nu > 0$ . In this game (whose extensive form is presented in figure 2), the principal does not know if the contract was bought by a Truth or a Dare (the proportion of Truths in the economy is  $1 - \xi$ ). When time comes for the principal to investigate or not, the only thing she knows is whether the agent requests unemployment benefits not; she does not know if she is facing a Dare who committed a crime, or an agent who is unemployed. Her strategy in case the agent request no benefits is simple: she does not investigate.

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

$$b_1 = 0 \tag{65}$$

$$b_2 = 0 \tag{66}$$

$$b_3 = \frac{\xi(1-\eta)}{(1-\xi) + \xi(1-\eta)} \tag{67}$$

$$b_4 = \frac{1-\xi}{(1-\xi) + \xi(1-\eta)} \tag{68}$$

When a benefit is requested, her beliefs are given as

$$a_1 = \frac{\pi(1-\xi)}{\pi + \xi(1-\pi)\eta} \tag{69}$$

$$a_2 = \frac{\pi\xi}{\pi + \xi(1-\pi)\eta} \tag{70}$$

$$a_3 = \frac{\xi(1-\pi)\eta}{\pi + \xi(1-\pi)\eta} \tag{71}$$

$$a_4 = 0 \tag{72}$$

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<sup>13</sup>Recall that the case where  $\eta < 1$  and  $\nu = 0$  is not a sustainable Nash equilibrium because it is dominated by the case  $\eta = 1$  and  $\nu = 0$ .

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

$$(-c - \beta_{\eta\nu})(1 - a_3) + (-c)a_3 = -\beta_{\eta\nu} \quad (73)$$

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

Using (71), the probability that a Dare commits a crime is given by<sup>14</sup>

$$\eta = \frac{\pi}{(1 - \pi)\xi} \left( \frac{c}{\beta_{\eta\nu} - c} \right) \quad (74)$$

The principal investigates with probability

$$\nu = \frac{U(Y + W - p_{\eta\nu} + \beta_{\eta\nu}) - U(Y + W - p_{\eta\nu})}{U(Y + W - p_{\eta\nu} + \beta_{\eta\nu}) - U(Y + W - p_{\eta\nu}) + k} \quad (75)$$

The beliefs of the principal in each information node are then

$$a_1 = (1 - \xi) \frac{\beta_{\eta\nu} - c}{\beta_{\eta\nu}} \quad (76)$$

$$a_2 = \xi \frac{\beta_{\eta\nu} - c}{\beta_{\eta\nu}} \quad (77)$$

$$a_3 = \frac{c}{\beta_{\eta\nu}} \quad (78)$$

$$a_4 = b_1 = b_2 = 0 \quad (79)$$

$$b_3 = \frac{\xi(1 - \pi)(\beta_{\eta\nu} - c) - c}{(1 - \pi)\beta_{\eta\nu} - c} \quad (80)$$

$$b_4 = \frac{(1 - \xi)(1 - \pi)(\beta_{\eta\nu} - c)}{(1 - \pi)\beta_{\eta\nu} - c} \quad (81)$$

Note that for (80) and (81) to be between zero and one the proportion of Dares,  $\xi$ , 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

$$p_{\eta\nu} = (1 - \xi)\pi(\beta_{\eta\nu} + c\nu) + \xi[\pi\beta_{\eta\nu} + (1 - \pi)\beta_{\eta\nu}\eta(1 - \nu) + c\nu[\pi + (1 - \pi)\eta]] \quad (82)$$

The problem faced by the principal is then

$$\max_{p_{\eta\nu}, \beta_{\eta\nu}} EU_{\eta\nu} = \pi U(Y - p_{\eta\nu} + \beta_{\eta\nu}) + (1 - \pi)U(Y + W - p_{\eta\nu}) \quad (83)$$

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<sup>14</sup>By construction,  $\eta < 1$  in this part of the proof construction so that it must be that  $\xi > \frac{\pi}{1 - \pi} \left( \frac{c}{\beta_{\eta\nu} - c} \right)$ .

subject to

$$p_{\eta\nu} = (1 - \xi) \pi (\beta_{\eta\nu} + c\nu) + \xi [\pi\beta_{\eta\nu} + (1 - \pi)\beta_{\eta\nu}\eta(1 - \nu) + c\nu[\pi + (1 - \pi)\eta]] \quad (84)$$

$$\eta = \frac{1}{\xi} \left( \frac{\pi}{1 - \pi} \right) \left( \frac{c}{\beta_{\eta\nu} - c} \right) \quad (85)$$

$$\nu = \frac{U(Y + W - p_{\eta\nu} + \beta_{\eta\nu}) - U(Y + W - p_{\eta\nu})}{U(Y + W - p_{\eta\nu} + \beta_{\eta\nu}) - U(Y + W - p_{\eta\nu}) + k} \quad (86)$$

Substituting for the PBNE constraints yields

$$\max_{p_{\eta\nu}, \beta_{\eta\nu}} EU_{\eta\nu} = \pi U(Y - p_{\eta\nu} + \beta_{\eta\nu}) + (1 - \pi)U(Y + W - p_{\eta\nu}) \quad (87)$$

subject to

$$p_{\eta\nu} = \pi \frac{\beta_{\eta\nu}^2}{\beta_{\eta\nu} - c} \quad (88)$$

This maximization problem is exactly the same that the Criminal faces in an economy with full information (see equation 29 and Proposition 2). We can therefore say that if  $\xi > \bar{\xi} = \frac{\pi}{1 - \pi} \left( \frac{c}{\beta_{\eta\nu} - c} \right)$ , then the contract does not vary with the proportion of Dares in the economy.

**PART 2.** Suppose  $\eta = 1$  and  $\nu > 0$ . This means that the problem faced by the principal is

$$\max_{p_{0\nu}, \beta_{0\nu}, \nu_{0\nu}} EU_{0\nu} = \pi U(Y - p_{0\nu} + \beta_{0\nu}) + (1 - \pi)U(Y + W - p_{0\nu}) \quad (89)$$

subject to

$$p_{0\nu} = (1 - \xi) \pi \beta_{0\nu} + \xi [\pi\beta_{0\nu} + (1 - \pi)\beta_{0\nu}(1 - \nu_{0\nu})] + c\nu [\xi + \pi(1 - \xi)] \quad (90)$$

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

$$\frac{\partial EU_{0\nu}}{\partial p_{0\nu}} = 0 = - [\pi U'(Y - p_{0\nu} + \beta_{0\nu}) + (1 - \pi)U'(Y + W - p_{0\nu})] + \lambda_{0\nu} \quad (91)$$

$$\frac{\partial EU_{0\nu}}{\partial \beta_{0\nu}} = 0 = \pi U'(Y - p_{0\nu} + \beta_{0\nu}) - \lambda_{0\nu} [\pi + \xi(1 - \pi)(1 - \nu_{0\nu})] \quad (92)$$

$$\frac{\partial EU_{0\nu}}{\partial \nu_{0\nu}} = 0 = \lambda_{0\nu} [\xi(1 - \pi)\beta_{0\nu} - c(\xi + \pi(1 - \xi))] \quad (93)$$

Solving yields the desired results.

**PART 3.** Suppose  $\eta = 1$  and  $\nu = 0$ . This means that the problem faced by the principal is

$$\max_{p_{00}, \beta_{00}} EU_{00} = \pi U(Y - p_{00} + \beta_{00}) + (1 - \pi)U(Y + W - p_{00}) \quad (94)$$

subject to

$$p_{00} = (1 - \xi) \pi \beta_{00} + \xi \beta_{00} \quad (95)$$

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

$$\frac{\partial EU_{00}}{\partial p_{00}} = 0 = - [\pi U' (Y - p_{00} + \beta_{00}) + (1 - \pi) U' (Y + W - p_{00})] + \lambda_{00} \quad (96)$$

$$\frac{\partial EU_{00}}{\partial \beta_{00}} = 0 = \pi U' (Y - p_{00} + \beta_{00}) - \lambda_{00} [\pi (1 - \xi) + \xi] \quad (97)$$

Solving yields

$$\frac{U' (Y - p_{00} + \beta_{00})}{\pi U' (Y - p_{00} + \beta_{00}) + (1 - \pi) U' (Y + W - p_{00})} = 1 + \xi \frac{1 - \pi}{\pi} \quad (98)$$

which is the desired result.

## 9.6 Proof of Theorem 2

Define

$$\begin{aligned} EU_{00} &= \pi U (Y - p_{00}^* + \beta_{00}^*) + (1 - \pi) U (Y + W - p_{00}^*) \\ EU_{0\nu} &= \pi U (Y - p_{0\nu}^* + \beta_{0\nu}^*) + (1 - \pi) U (Y + W - p_{0\nu}^*) \\ EU_{\eta\nu} &= \pi U (Y - p_{\eta\nu}^* + \beta_{\eta\nu}^*) + (1 - \pi) U (Y + W - p_{\eta\nu}^*) \end{aligned}$$

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

**PART 1.** For this part of the proof, I want to show that

$$EU_{00} - EU_{0\nu} = \left[ \begin{array}{l} \pi U (Y - p_{00}^* + \beta_{00}^*) + (1 - \pi) U (Y + W - p_{00}^*) \\ - \pi U (Y - p_{0\nu}^* + \beta_{0\nu}^*) - (1 - \pi) U (Y + W - p_{0\nu}^*) \end{array} \right] \geq 0 \quad (99)$$

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

Let's find the point where  $EU_{00} - EU_{0\nu}$  is the smallest. The partial derivative of  $EU_{00} - EU_{0\nu}$  with respect to  $c$  is

$$\begin{aligned} \frac{\partial (EU_{00} - EU_{0\nu})}{\partial c} &= - \frac{\partial p_{00}^*}{\partial c} [\pi U' (Y - p_{00}^* + \beta_{00}^*) + (1 - \pi) U' (Y + W - p_{00}^*)] \\ &\quad + \frac{\partial \beta_{00}^*}{\partial c} \pi U (Y - p_{00}^* + \beta_{00}^*) - \frac{\partial \beta_{0\nu}^*}{\partial c} \pi U (Y - p_{0\nu}^* + \beta_{0\nu}^*) \\ &\quad + \frac{\partial p_{0\nu}^*}{\partial c} [\pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) + (1 - \pi) U' (Y + W - p_{0\nu}^*)] \end{aligned} \quad (100)$$

This is continuous for all  $c > 0$ .

$$\begin{aligned} \frac{\partial (EU_{00} - EU_{0\nu})}{\partial c} &= \frac{\partial p_{0\nu}^*}{\partial c} [\pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) + (1 - \pi) U' (Y + W - p_{0\nu}^*)] \\ &\quad - \frac{\partial \beta_{0\nu}^*}{\partial c} \pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) \end{aligned} \quad (101)$$

Since  $\frac{\partial p_{00}^*}{\partial c} = \frac{\partial \beta_{00}^*}{\partial c} = 0$ . We know that  $\frac{\partial p_{0\nu}^*}{\partial c} = [\pi(1 - \xi) + \xi] \frac{\partial \beta_{0\nu}^*}{\partial c}$  since  $p_{0\nu}^* = [\pi(1 - \xi) + \xi] \beta_{0\nu}^*$ . 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  $\frac{\partial^2 p_{0\nu}^*}{\partial c^2} = \frac{\partial^2 \beta_{0\nu}^*}{\partial c^2} = 0$ . As a consequence,

$$\begin{aligned} \frac{\partial (EU_{00} - EU_{0\nu})}{\partial c} &= [\pi(1 - \xi) + \xi] \frac{\partial \beta_{0\nu}^*}{\partial c} [\pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) + (1 - \pi) U' (Y + W - p_{0\nu}^*)] \\ &\quad - \frac{\partial \beta_{0\nu}^*}{\partial c} \pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) \end{aligned} \quad (102)$$

Finding the optimum yields

$$\frac{U' (Y - p_{0\nu}^* + \beta_{0\nu}^*)}{\pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) + (1 - \pi) U' (Y + W - p_{0\nu}^*)} = 1 + \xi \frac{(1 - \pi)}{\pi} \quad (103)$$

which is the solution to Proposition 3 (equation 19). This means that the only optimum of  $EU_{00} - EU_{0\nu}$  is found at the equilibrium value of  $\eta = 1$  and  $\nu = 0$  so 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

$$\begin{aligned} \frac{\partial^2 (EU_{00} - EU_{0\nu})}{\partial c^2} &= -\frac{\partial^2 \beta_{0\nu}^*}{\partial c^2} \pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) - \frac{\partial \beta_{0\nu}^*}{\partial c} \left[ \frac{\partial \beta_{0\nu}^*}{\partial c} - \frac{\partial p_{0\nu}^*}{\partial c} \right] \pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) \\ &\quad + \frac{\partial^2 p_{0\nu}^*}{\partial c^2} [\pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) + (1 - \pi) U' (Y + W - p_{0\nu}^*)] \\ &\quad + \frac{\partial p_{0\nu}^*}{\partial c} \left[ \pi \left[ \frac{\partial \beta_{0\nu}^*}{\partial c} - \frac{\partial p_{0\nu}^*}{\partial c} \right] U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) - (1 - \pi) \frac{\partial p_{0\nu}^*}{\partial c} U' (Y + W - p_{0\nu}^*) \right] \end{aligned} \quad (104)$$

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

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

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

$$\frac{U' (Y - p_{0\nu}^* + \beta_{0\nu}^*)}{\pi U' (Y - p_{0\nu}^* + \beta_{0\nu}^*) + (1 - \pi) U' (Y + W - p_{0\nu}^*)} = 1 + \xi \frac{(1 - \pi)}{\pi} \quad (105)$$

which is where  $\nu = 0$ .

**PART 2.** The second part of the proof shows that there exists a  $\tilde{\xi}$  such that for all  $\xi \leq \tilde{\xi}$

$$EU_{00} - EU_{\eta\nu} = \left[ \begin{array}{l} \pi U(Y - p_{00}^* + \beta_{00}^*) + (1 - \pi)U(Y + W - p_{00}^*) \\ -\pi U(Y - p_{\eta\nu}^* + \beta_{\eta\nu}^*) - (1 - \pi)U(Y + W - p_{\eta\nu}^*) \end{array} \right] \geq 0 \quad (106)$$

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

$$EU_{00} - EU_{\eta\nu} = \left[ \begin{array}{l} \pi U(Y - p_{00}^* + \beta_{00}^*) + (1 - \pi)U(Y + W - p_{00}^*) \\ -\pi U(Y - p_{\eta\nu}^* + \beta_{\eta\nu}^*) - (1 - \pi)U(Y + W - p_{\eta\nu}^*) \end{array} \right] \leq 0 \quad (107)$$

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  $\bar{\xi}$  such that  $EU_{00} - EU_{\eta\nu} = 0$ . Furthermore, if  $EU_{00} - EU_{\eta\nu}$  is monotone, then this  $\bar{\xi}$  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  $\xi$ . This gives us

$$\begin{aligned} \frac{\partial(EU_{00} - EU_{\eta\nu})}{\partial\xi} &= \pi U'(Y - p_{00}^* + \beta_{00}^*) \left[ \frac{\partial\beta_{00}^*}{\partial\xi} - \frac{\partial p_{00}^*}{\partial\xi} \right] + (1 - \pi)U'(Y + W - p_{00}^*) \left[ -\frac{\partial p_{00}^*}{\partial\xi} \right] \\ &\quad - \pi U'(Y - p_{\eta\nu}^* + \beta_{\eta\nu}^*) \left[ \frac{\partial\beta_{\eta\nu}^*}{\partial\xi} - \frac{\partial p_{\eta\nu}^*}{\partial\xi} \right] - (1 - \pi)U'(Y + W - p_{\eta\nu}^*) \left[ -\frac{\partial p_{\eta\nu}^*}{\partial\xi} \right] \end{aligned} \quad (108)$$

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  $\xi$  since  $p_{00}^* = [\pi(1 - \xi) + \xi]\beta_{00}^*$ , and  $\beta_{00}^*$  solves

$$\frac{U'(Y - [\pi(1 - \xi) + \xi]\beta_{00}^* + \beta_{00}^*)}{\pi U'(Y - [\pi(1 - \xi) + \xi]\beta_{00}^* + \beta_{00}^*) + (1 - \pi)U'(Y + W - [\pi(1 - \xi) + \xi]\beta_{00}^*)} = 1 + \xi \frac{1 - \pi}{\pi} \quad (109)$$

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

$$0 \geq \pi U(Y - p_{00}^* + \beta_{00}^*) \left[ \frac{\partial\beta_{00}^*}{\partial\xi} - \frac{\partial p_{00}^*}{\partial\xi} \right] + (1 - \pi)U(Y + W - p_{00}^*) \left[ -\frac{\partial p_{00}^*}{\partial\xi} \right] \quad (110)$$

and

$$\frac{\partial\beta_{00}^*}{\partial\xi} \leq \frac{\beta_{00}^*}{1 + \xi \frac{1 - \pi}{\pi}} \quad (111)$$

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

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

## 9.7 Proof of Proposition 4

Again, I divide this proof into parts.

**PART 1.** Suppose  $\xi > \bar{\xi} = \frac{\pi}{1-\pi} \left( \frac{c}{\beta_{\eta\nu}-c} \right)$ . When there are no Truths in the economy, we know that the probability that a Dare commits a crime is

$$E(\eta) = \eta = \left( \frac{\pi}{1-\pi} \right) \left( \frac{c}{\beta-c} \right) \quad (112)$$

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

$$E(\eta/D) = \frac{\pi}{(1-\pi)\xi} \left( \frac{c}{\beta-c} \right) \quad (113)$$

When I include the fact that the probability that a contract is bought by a Criminal is given by  $\xi$ , the probability that a fraudulent claim is filed becomes

$$E(\eta) = \xi \frac{\pi}{(1-\pi)\xi} \left( \frac{c}{\beta-c} \right) = \eta \quad (114)$$

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. Because the probability of investigation is independent of the proportion of each type of agent in the economy,

$$\nu = \frac{U(Y+W-p+\beta) - U(Y+W-p)}{U(Y+W-p+\beta) - U(Y+W-p) + k} \quad (115)$$

and because  $\eta$  is independent of  $\xi$ , it follows that the probability a crime remains undetected,  $\eta(1-\nu)$ , is independent of  $\xi$ .

**PART 2.** For the second case, when  $\xi \leq \bar{\xi} = \frac{\pi}{1-\pi} \left( \frac{c}{\beta_{\eta\nu}-c} \right)$ , all Dares commit fraud so that  $\eta = 1$ . In that case the unconditional probability of fraud is  $\xi$ . 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 investigation is ever conducted when  $\xi \leq \bar{\xi}$ .

FIGURE 3A

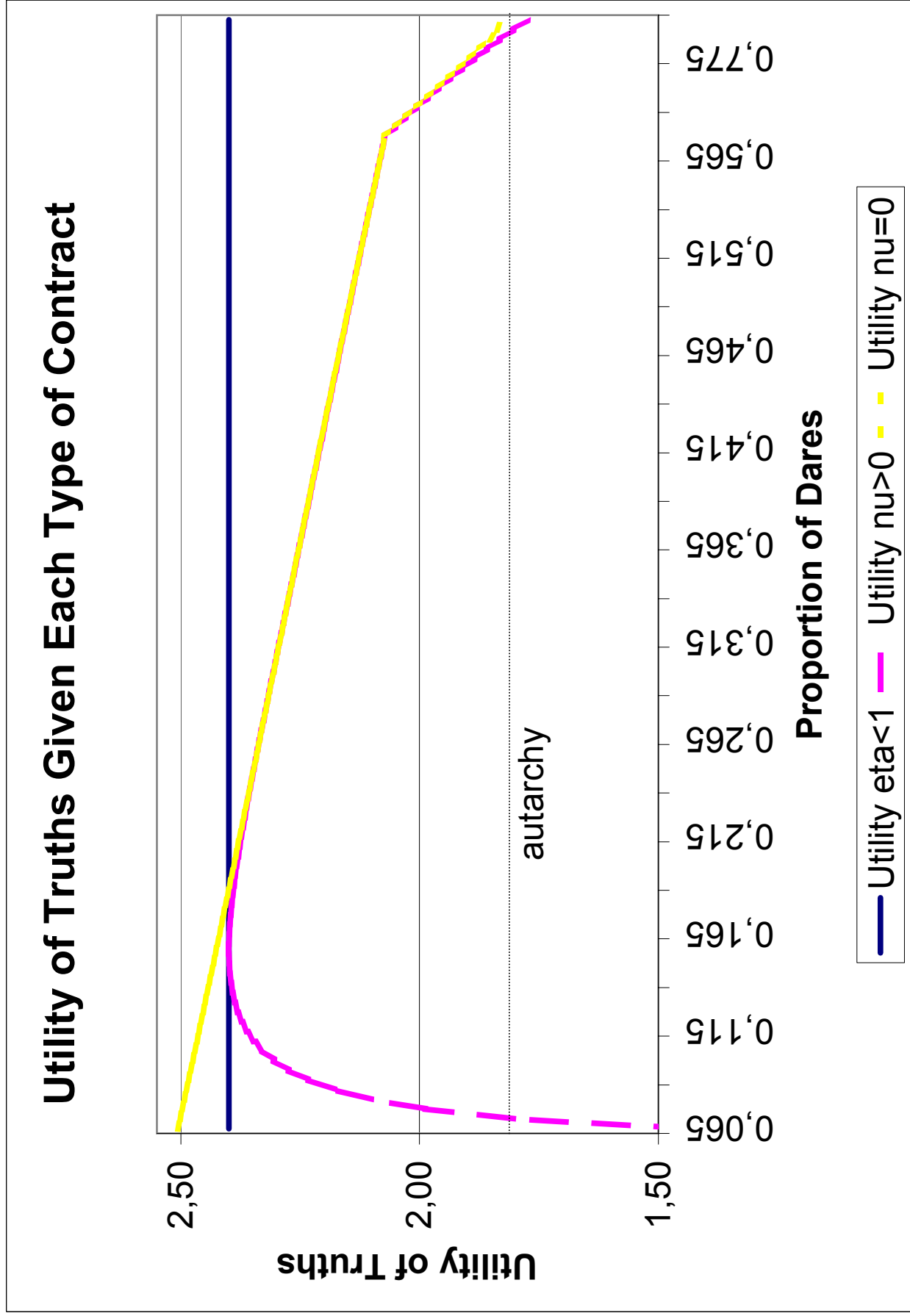


FIGURE 3B

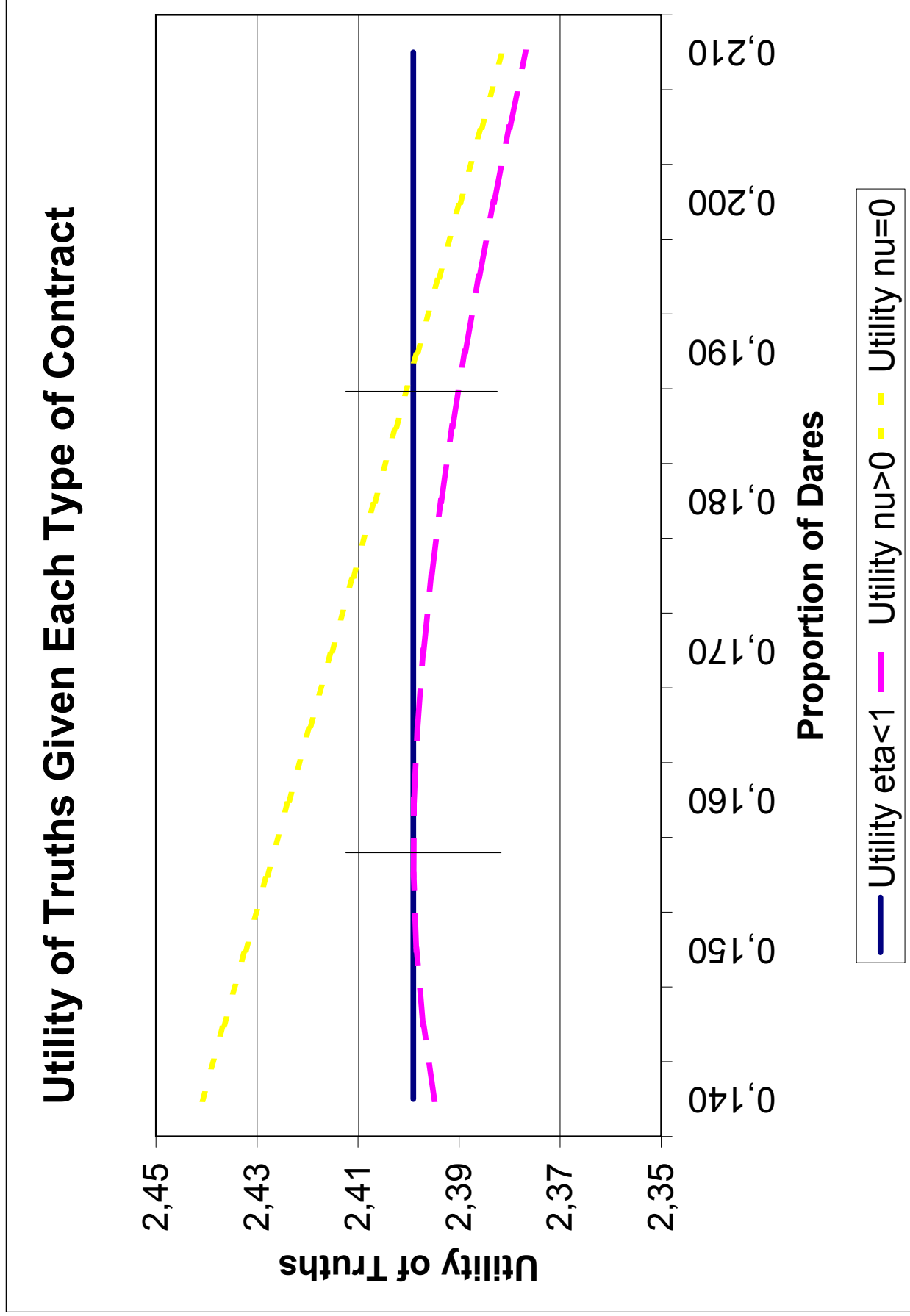


FIGURE 4

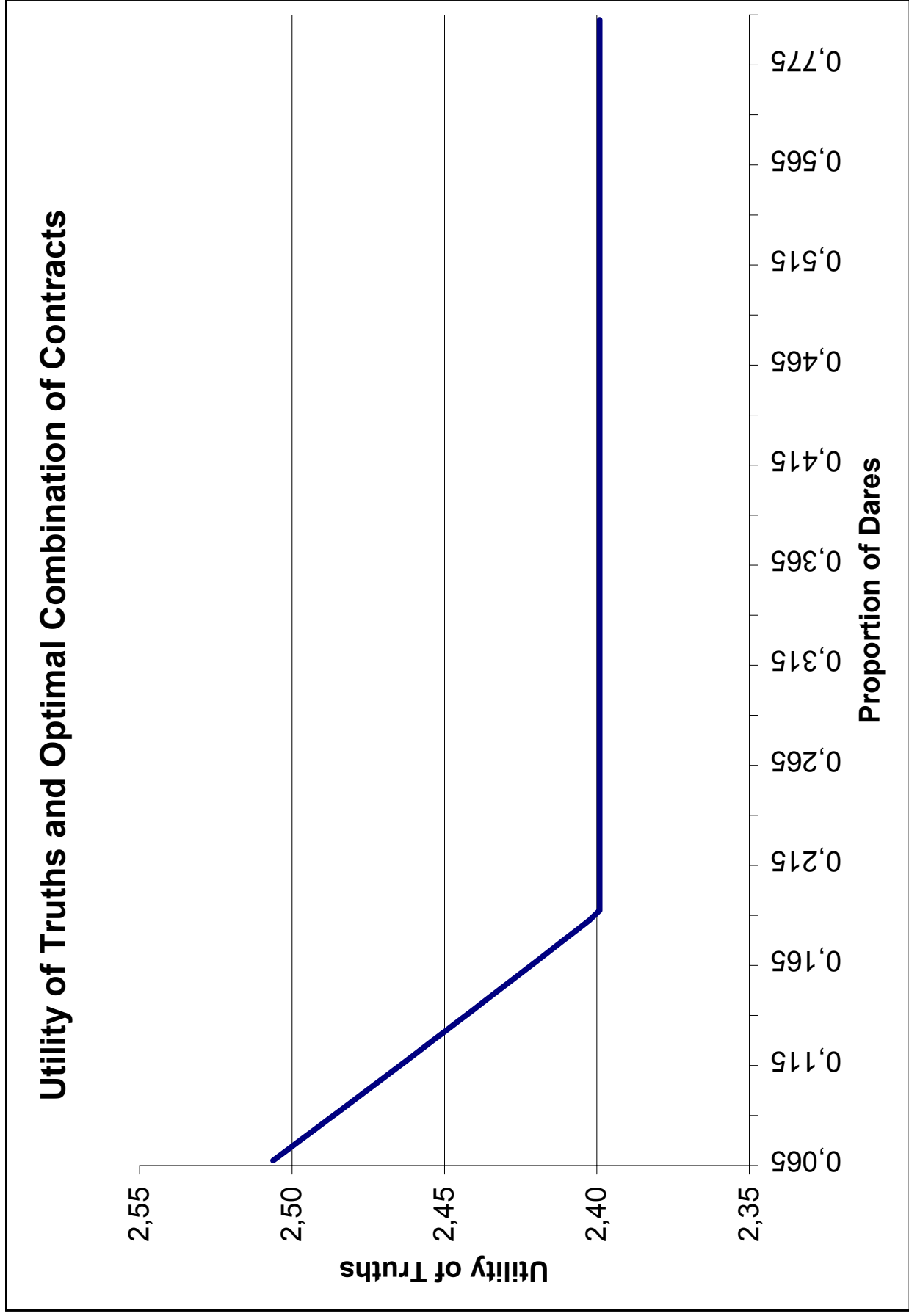


FIGURE 5

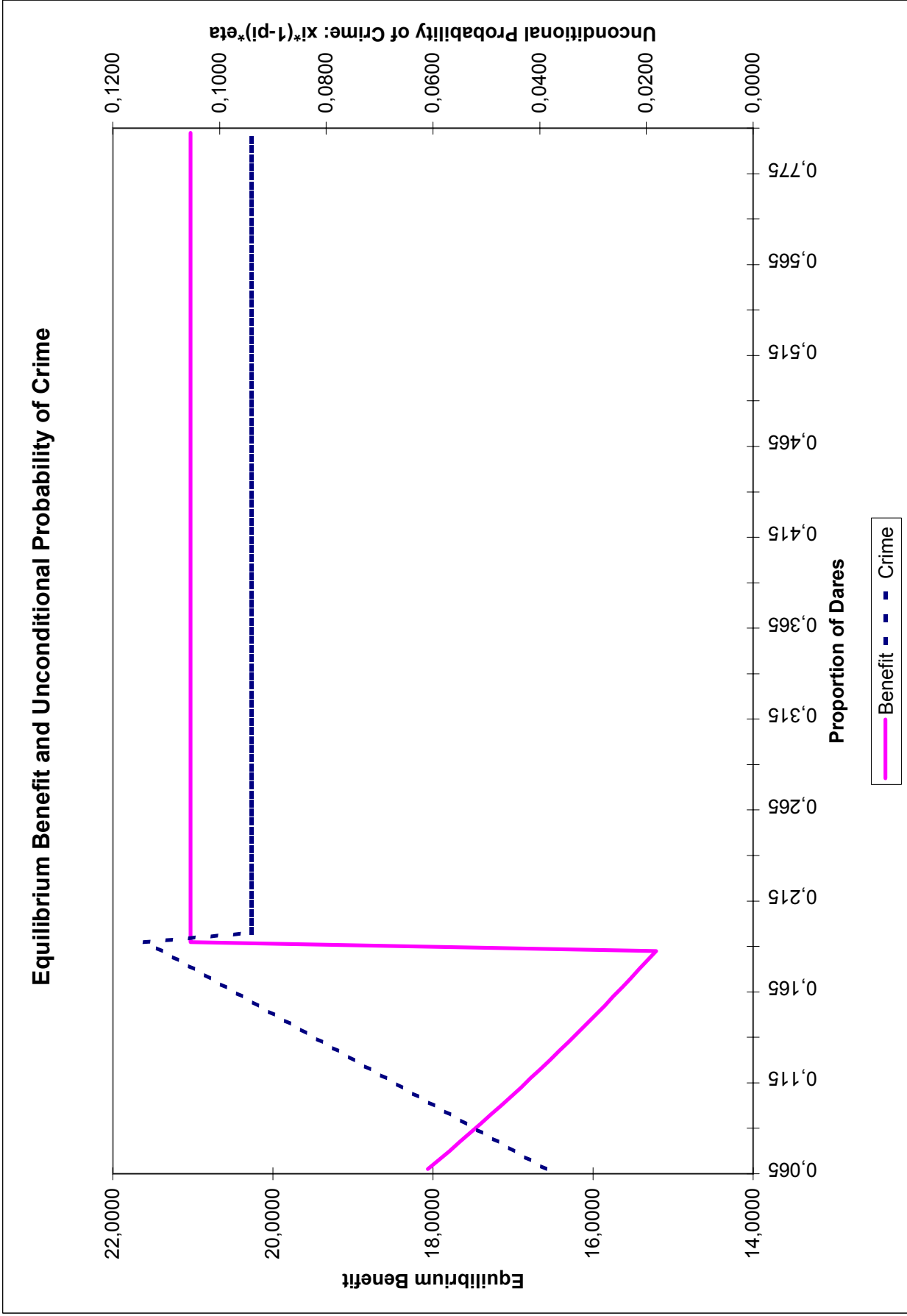


FIGURE 6

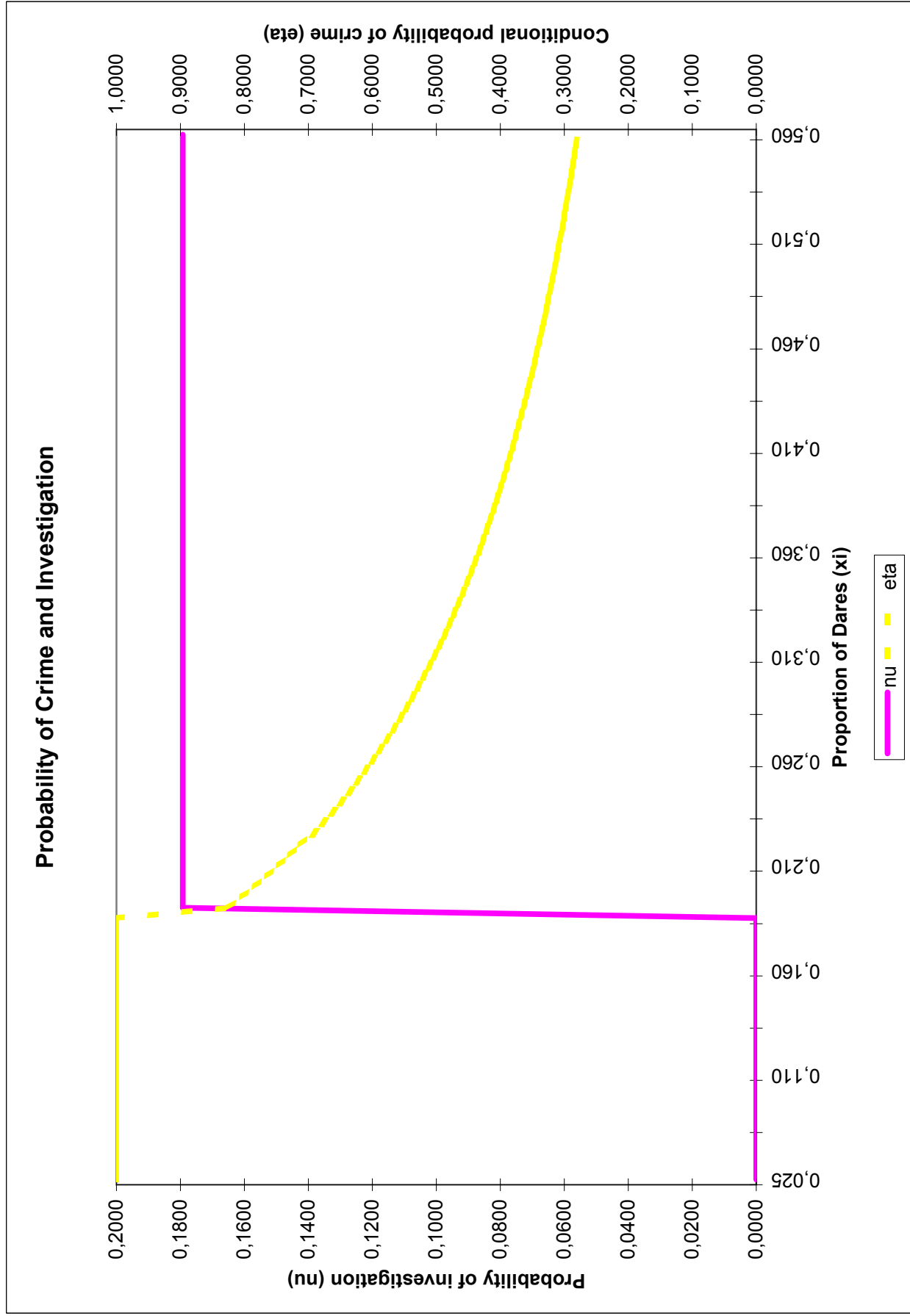


FIGURE 7

### Utility of Truths Given Each Type of Contract: Investment in prevention

