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Resistance (to Fraud) Is Futile

M. Martin Boyer

Abstract

This article 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. Furthermore, if the proportion of Dares is large enough, then the pooling contract, the amount of fraud and the number of agents found to have committed fraud are independent of the Dares' exact proportion in the economy. Finally, I show that investment in prevention can be useless if the proportion of Dares is large enough, which means 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.

Introduction

Crime, crime prevention, and crime punishment have always represented a major concern of any society. In the United States, almost 7 percent of the male workforce is under the supervision of the American penal system: 2 percent of the male workforce is incarcerated whereas another 5 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 3 percent 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 percent of total claims (see Weisberg and Derrig, 1991; 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

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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 percent discount rate) of automobile insurance fraud in the United States is 220 billions dollars, which is almost three times the stock market value of Enron at the end of 2000. Irrespective of unemployment insurance fraud, worker's compensation fraud and other types of fraud in life, health, and property insurance, 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; Friedman, 1999).[1] In an insurance context, however, Becker's philosopher-king approach, with an infinite penalty and a commitment to a prespecified investigation policy,[2] cannot hold for two reasons.

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), Picard (1996), and Boyer (2004) it is not be 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 (2001) reach similar conclusions. In these articles 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.[3]

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[1] 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.

[2] See Saha and Poole (2000) and Reinganum (2000) for a recent assessment of sentencing guidelines and penalties.

[3] Although my analysis is purely static as the game is played only once after which the players die, I partially address dynamic considerations in the section "Dynamic Considerations." The main results do not vary significantly.

This modeling approach can be applied to many insurance frameworks such as automobile insurance, social security, health insurance, and unemployment insurance (see Mookherjee and Png, 1989; Picard, 1996; Bond and Crocker, 1997; Boyer, 2001). Reinganum and Wilde (1985) also use this approach to study income tax fraud.

The model includes implicitly an agent's propensity to commit fraud; 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." My model is thus greatly inspired by that of Picard (1996) in an automobile insurance context. Contrary to Picard (1996), however, I do not find instances when the insurance market collapses because the proportion of criminal elements in the economy is too large. Moreover, I address the issue of the presence of a technology that reduces the incidence of insurance fraud. I model prevention as a device that turns Dares into Truths.

The results of the article 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. Second, 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. Moreover, this pooling contract has exactly the same structure as the contract observed when there is a proportional loading factor on the premium. Third, when $\xi > \xi^*$, the pooling contract is independent of the exact proportion of Dares. As a result, the agents' expected utility is independent of ξ provided that $\xi > \xi^*$. Fourth, when $\xi > \xi^*$, not only is the sunk cost penalty irrelevant in determining the amount of fraud in the economy, prevention also has no impact on the amount of fraud.

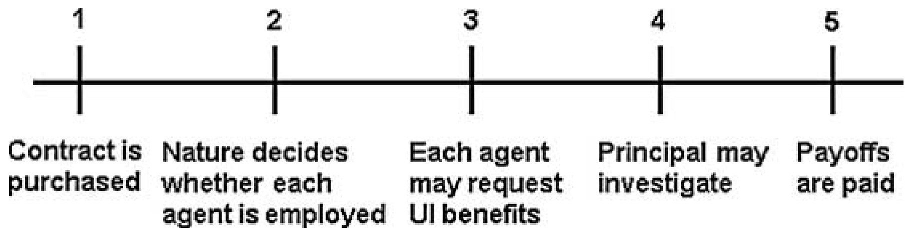
The article is constructed as follows. In the next section, I present the setup of the game between the agents and the principal. In the section "Optimal Contract When the Type Is Known" I present the benchmark case where each agent's type is common knowledge. I let each agent's type be private information in the section "Optimal Contract When Types Are Unknown" 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 the section "Fraud Prevention." The section "Dynamic Considerations" briefly discusses dynamic considerations. The final section concludes and leaves room for further research.

ASSUMPTIONS AND SETUP

In an unemployment insurance framework—the setup for automobile fraud would be slightly different, but the articles main conclusions would be the same—suppose a one-shot game between a risk neutral principal and risk averse agents. An agent may be of two types: "Truth" and "Dare." 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 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. The sequence of the game is presented in Figure 1.

In the first stage of the game agents are offered a menu of contracts that specify an unemployment insurance benefit β and a premium p. I assume that the unemployment insurance contract is actuarially fair so that the premium (p) is exactly equal to the

FIGURE 1
Sequence of Play



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.[4] If caught committing fraud the agent must incur some penalty. The sunk cost penalty is represented as some fixed disutility k,[5] such as prison time or reputationnal loss. Finally, the payoffs are paid and the game ends.

OPTIMAL CONTRACT WHEN THE TYPE IS KNOWN

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.[6]

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.

[4] The cost of investigation is modeled as a pure marginal cost. In reality, fraud investigation units have important fixed costs that are not modeled here. Their modeling would necessitate that I include a financing mechanism (i.e., taxes) for these fraud units that are beyond the scope of this article. See Boyer (2001) for details related to the impact of different tax schemes on the amount of fraud in the economy.

[5] 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 later.

[6] All proofs are in the Appendix.

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*	$U(Y - p)$	$p - c$
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	$U(Y - p + \beta)$	$p - \beta$

Notes: States in italics never occur in equilibrium as their corresponding actions are off the equilibrium path. The possible states of the world are for the agent to be employed or unemployed, the action of the Dare is to request insurance benefits or not request insurance benefits, and the action of the principal is to investigate the agent and not investigate. The table's parameters are defined as Y is the agent's initial wealth, W is the agent's wage when working, p is the insurance premium, β is the indemnity payment associated with the insurnace contract, c is the principal's cost of auditing, and k is the penalty paid by the agent when he is found to have committed fraud.

Dares

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

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 η be the probability that a Dare requests benefits when employed (i.e., the probability a Dare commits fraud), and let ν be the probability of investigating an agent who requests benefits. In equilibrium, η and ν are given by

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

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

Given those optimal strategies,[7] 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

[7] Note in particular, that $\frac{\partial \eta}{\partial \beta} < 0$ and that $\frac{\partial \nu}{\partial \beta} > 0$, which means that fraud (committed as well as successful) decreases when β increases.

agent and the fact that some fraud goes undetected, the fair price of this contract is given by

$$p = \pi\beta + (1-\pi)\beta\eta(1-\nu) + c\nu[\pi + (1-\pi)\eta], \tag{3}$$

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

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

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

Clearly, the probability of fraud (η) is independent of the premium (p). On the other hand, the probability the principal investigates (ν) depends on the benefits and the premium. By designing the optimal contract (p, β), 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*

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

Interestingly, the solution to this problem is such that the optimal benefit is greater than the amount at risk ($\beta > W$).[8] This is explained by the fact that the principal,

[8] This is easily shown theoretically. 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

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

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

who is unable to commit *ex ante* to an auditing strategy, must find a relatively credible mechanism that sends the message to the agent that she will audit. This costly message is sent by promising to pay greater benefits in case of unemployment. This message must be interpreted by the agent to mean that the principal will investigate with greater probability since she has more to lose by not doing so. Stated differently, the contract is designed so that the insurer implicitly commits to investigate more often agents who claim to be unemployed. Another interesting aspect of the equilibrium is that the number of successful fraudulent claims, measured by $\pi\eta\,(1-\nu)$, is negatively related to the indemnity payment. In other words, $\frac{\partial}{\partial\beta}\pi\eta(1-\nu) < 0$, so that increasing benefits decreases fraud.[9]

Using Proposition 2, Corollary 1 follows.

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., β 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 β, it follows that the sunk cost penalty has no impact on the amount of fraud in the economy. Similarly to Khalil (1997) and Boyer (2004), 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 (see also Picard, 1996; Khalil, 1997; Boyer, 2004). 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.

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

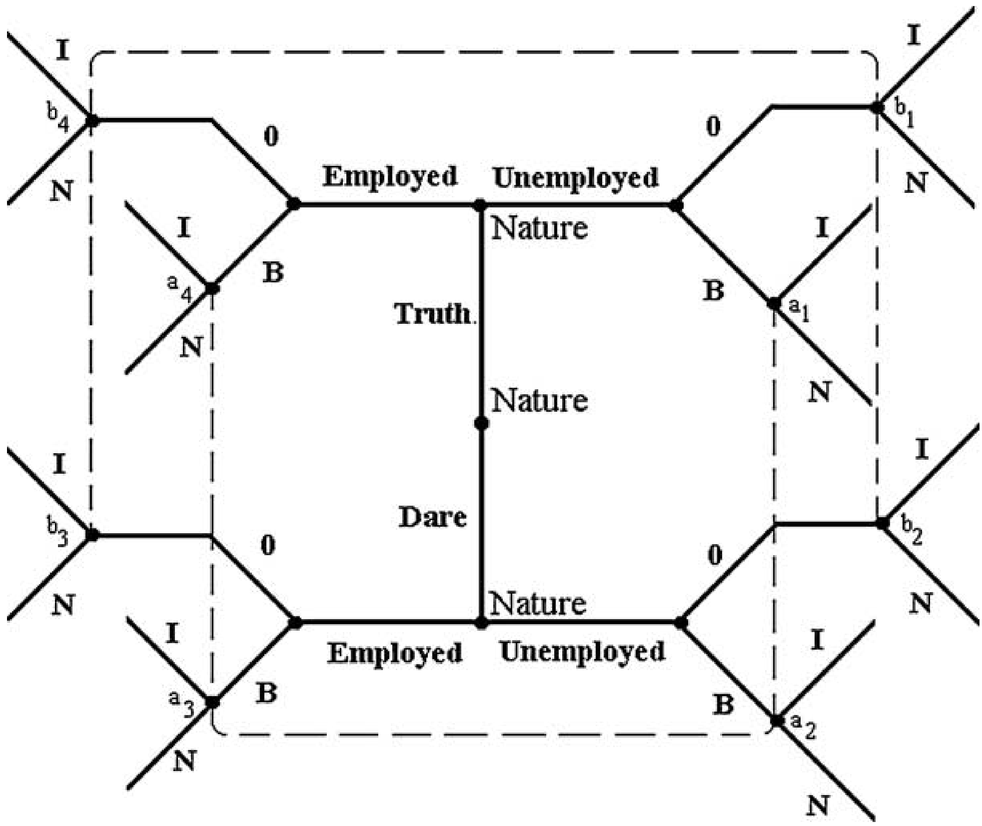
$$\max_{p,\beta} EU = \pi U(Y-p+\beta) + (1-\pi)U(Y+W-p) \quad \text{Subject to } p = \pi\frac{\beta(\beta+m)}{\beta+m-c}.$$

Clearly, the sunk cost penalty k still has no impact on the optimal contract.[10]

[9] This somewhat surprising result can be reconciled with reality (i.e., where overcompensation does not occur) if one is to add a large enough proportional loading factor to the premium as in Boyer (2003).

[10] Karpoff and Lott (1993), Waldfogel (1994), and Grogger (1995) show that the reputationnal loss (by definition a purely sunk loss) associated with a criminal conviction far outweights

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



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?

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. In this game *B*

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 percent, 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 percent and −5.05 percent depending on the type of fraud; this represents more than 10 times the sum of any fine, penalty, or court-imposed costs.

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, a separating contract maximizes the following problem:

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

subject to

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

$$\pi U(Y - p_T + \beta_T) + (1-\pi)U(Y + W - p_T) \geq \pi U(Y) + (1-\pi)U(Y + W) \tag{8}$$

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

$$\begin{aligned} &\pi U(Y - p_T + \beta_T) + (1-\pi)U(Y + W - p_T) \\ &\quad \geq \pi U(Y - p_D + \beta_D) + (1-\pi)U(Y + W - p_D) \end{aligned} \tag{10}$$

$$(1-\xi)p_T + \xi p_D = (1-\xi)\pi\beta_T + \xi[\pi\beta_D + (1-\pi)\beta_D\eta(1-\nu) + c\nu(\pi + (1-\pi)\eta)] \tag{11}$$

$$\eta, \nu \in [0, 1] \tag{12}$$

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 and Equation (11) is the principal's resource constraint, with ξ being the proportion of Dares in the economy. The boundary conditions on the probability of committing fraud and of investigating are given in (12).

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

Proposition 3: *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 makes no profit in aggregate, then 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 premium paid to purchase the insurance contract must be such that

$$p = \pi\beta + \xi(1-\pi)\beta\eta(1-\nu) + c\xi\nu(\pi + (1-\pi)\eta). \tag{13}$$

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 the principal investigates only with some probability given that an agent has requested benefits. 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.[11] I derive the optimal contract for the different situations in the next proposition.

Proposition 4:

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

$$\nu^*_{0\nu} = 1 - \frac{\pi}{\xi}\frac{U'(Y - p^*_{0\nu} + \beta^*_{0\nu}) - U'(Y + W - p^*_{0\nu})}{\pi U'(Y - p^*_{0\nu} + \beta^*_{0\nu}) + (1-\pi)U'(Y + W - p^*_{0\nu})} \tag{14}$$

$$p^*_{0\nu} = c\left(\frac{[\pi + \xi(1-\pi)]^2}{\xi(1-\pi)}\right) = \pi\beta^*_{0\nu}\left[1 + \xi\left(\frac{1-\pi}{\pi}\right)\right] \tag{15}$$

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

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

$$p^*_{00} = \pi\beta^*_{00}\left[1 + \xi\left(\frac{1-\pi}{\pi}\right)\right] \tag{17}$$

[11] 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.

and β^*_{00} *solves*

$$\frac{U'\big(Y - p^*_{00} + \beta^*_{00}\big)}{\pi U'\big(Y - p^*_{00} + \beta^*_{00}\big) + (1-\pi)U'\big(Y + W - p^*_{00}\big)} = 1 + \xi\left(\frac{1-\pi}{\pi}\right). \tag{18}$$

Note that for the three types of contracts, the only endogenous variable is the benefit (β). 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 ξ^* and 1, the contract is the same as the one presented in Proposition 2.

When $\eta = 1$ and $\nu > 0$, the optimal contract does not depend on the principal's investigating strategy because 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 $\nu^*_{0\nu}$. The premium can then be written as if a proportional loading factor equal to $\xi\frac{1-\pi}{\pi}$ existed.

In the case of $\eta = 1$ and $\nu = 0$, again the only choice variable is β^*_{00}, since p^*_{00} is obtained directly from β^*_{00}. The functions that determine β^*_{00} and p^*_{00} (Equations 18 and 17) are the same as the one in the case of a proportional loading factor on the premium equal to $\xi\frac{1-\pi}{\pi}$. The first best insurance contract ($\beta^*_{00} = W$) occurs when $\xi \to 0$. The contract offered when $\eta = 1$ and $\nu = 0$ can thus be viewed as one where Truths find it more advantageous to let Dares extract a rent than to fight fraud.

Theorem 1 determines which contract applies when.

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

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 ν is $(1-\pi)\,(1-\nu)\beta + N\pi\nu\, c + (1-\pi)\nu\, c$.[12] Not investigating is then better when

$$(1-\pi)\beta \le (1-\pi)(1-\nu)\beta + N\pi\nu c + (1-\pi)\nu c. \tag{19}$$

This inequality holds if and only if $\beta \le (N\frac{\pi}{1-\pi} + 1)c$. This obviously holds as N gets large. It also holds as the auditing cost (c) is high.

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

[12] 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.

investigating. To illustrate, suppose there are D Dares in the economy. Investigating with probability ν is then optimal if and only if

$$D(1-\pi)\beta - D(1-\pi)(1-\nu)\beta - N\pi\nu c - D(1-\pi)\nu c \leq 0, \tag{20}$$

which holds when $\beta \leq (\frac{N}{D}\frac{\pi}{1-\pi}+1)c$. As the number of Dares (D) increases, this inequality is less likely to hold. The same can be said about the auditing cost when it is small.

An interesting situation that was first presented by Picard (1996) occurs when the cost of auditing (c) is large. Picard (1996) writes that the "*welfare loss for honest individuals . . . may even be so large that the insurance market completely shuts down*" (p. 27). This is not the case here. When the auditing cost is very large, the insurer decides never to audit, which means that the optimal contract is similar to a contract where there exists a proportional loading factor on the insurance premium equal to $\xi(\frac{1-\pi}{\pi})$. This proportional loading, as high as it could be (which is to be equal to $\frac{1-\pi}{\pi}$), can never be such that autarchy is prefered. Indeed, when the loading factor is proportional to the premium, the optimal contract is to have partial insurance, no matter what the proportional loading factor is.

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.[13] 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 $\nu > 0$.

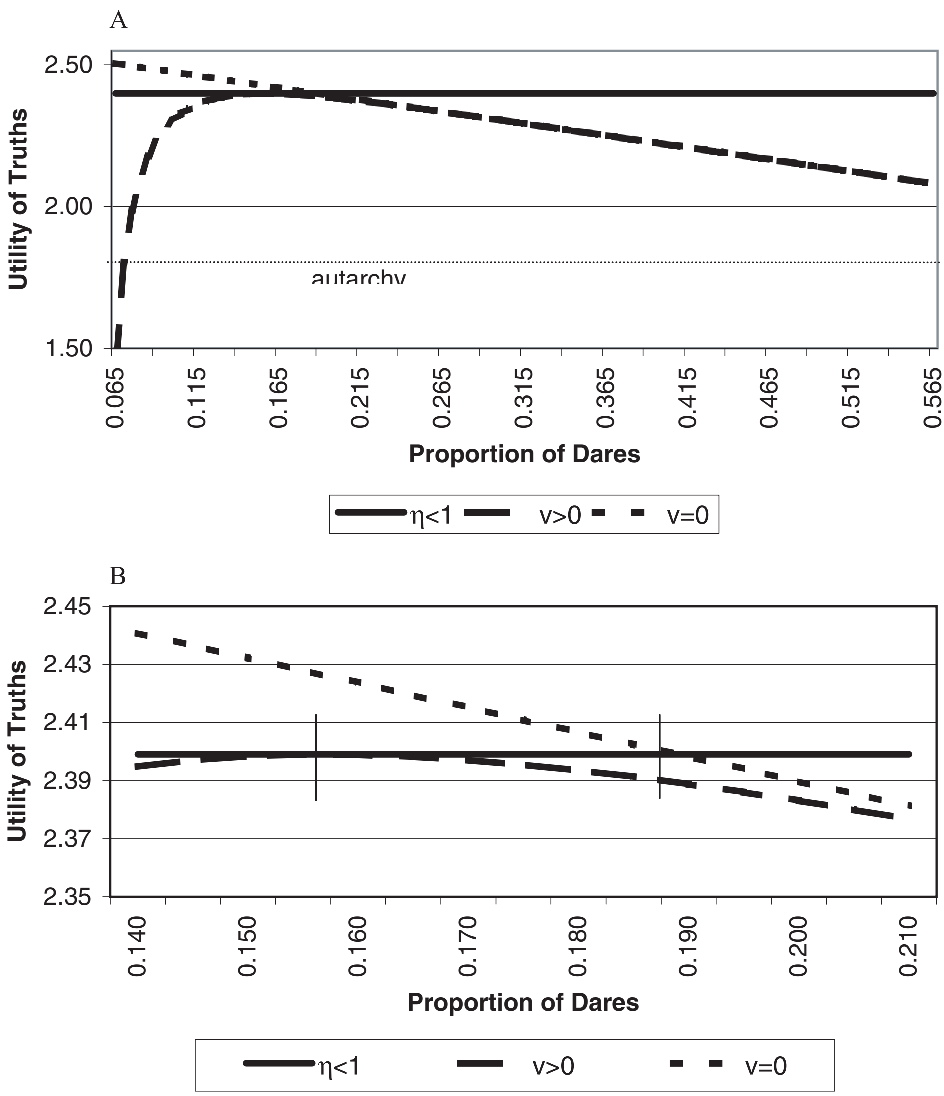
Figure 3A also shows that for lower values of ξ the expected utility of Truths is highest when $\eta = 1$ and $\nu = 0$. For larger ξ, the Truths' expected utility is highest with $\eta < 1$ and $\nu > 0$. The two contracts yield the same expected utility when $\xi = \xi^*$ (the expected utility functions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

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 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 graph ($\xi > \xi^*$), the expected utility of agents is constant because Dares adjust their behavior as a function of ξ. As ξ increases beyond ξ^*(which lowers expected utility), the probability that any one Dare

[13] 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.

FIGURE 3
(A) Utility of Truths Given Each Type of Contract, (B) Utility of Truths Given Each Type of Contract



commits fraud decreases (which increases expected utility). In equilibrium, the two effects cancel out.

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 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, similar to the case where the principal knew the agent to be a Dare, the optimal benefit on the portion $\xi > \xi^*$ is such that the benefit is greater than the possible

FIGURE 4
Utility of Truths and Optimal Combination of Contracts

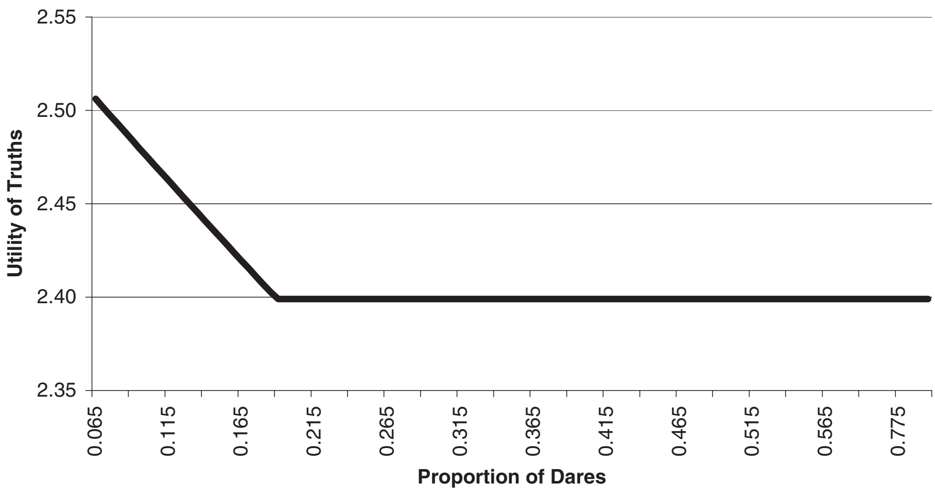
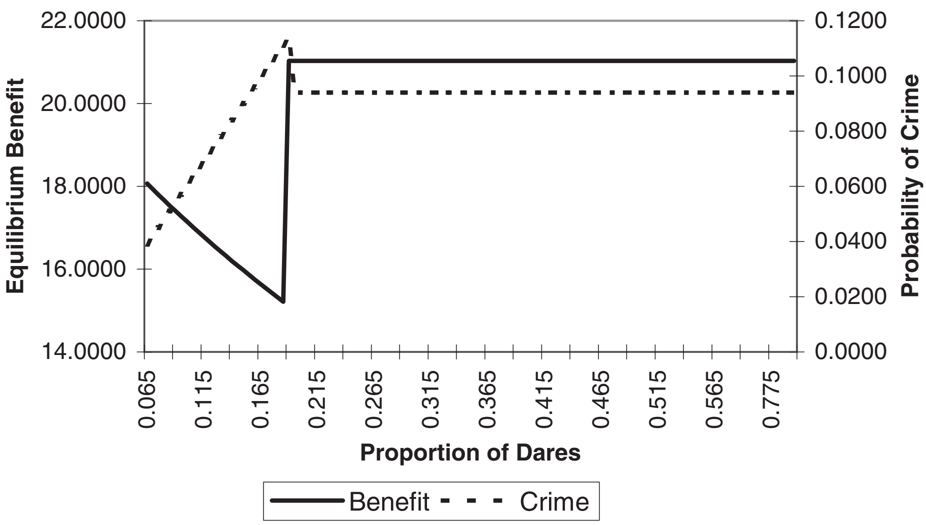


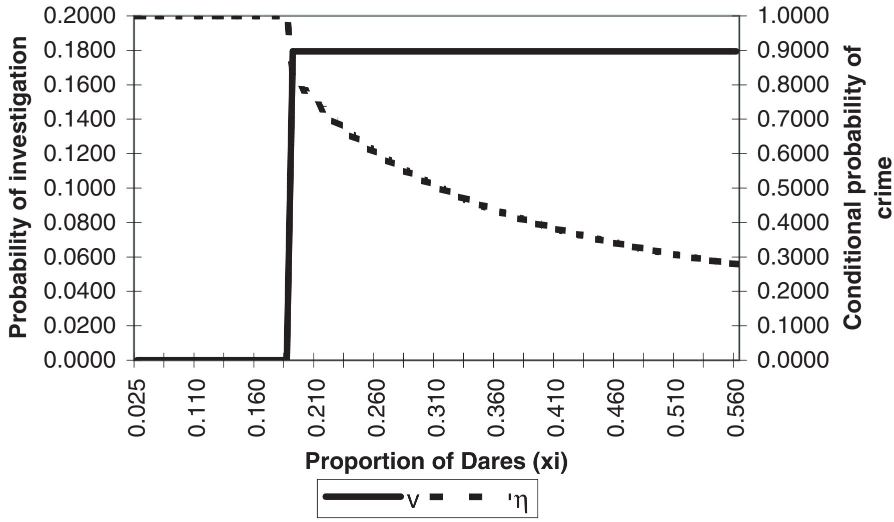
FIGURE 5
Equilibrium Benefit and Unconditional Probability of Crime



wage ($\beta > W$). By promising to pay greater benefits in case of unemployment, the principal implicitly sends a message that she will investigate with greater probability. 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 $\beta < W$.

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

FIGURE 6
Probability of Crime and Investigation



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

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 ν^* that is independent of ξ (see Equation (2)). As a result, there are only two possible probabilities of auditing: zero and ν^*. These are represented by the two horizontal lines. Regarding the probability of commiting fraud conditional on being a Dare, it is equal to one when $\xi < \xi^*$. When $\xi > \xi^*$, the probability that any Dare commits fraud, given by $\eta = (\frac{\pi}{1-\pi})(\frac{c}{\beta - c})\frac{1}{\xi}$ decreases even though the unconditional probability $\eta_u = \eta\,\xi$ remains constant. Consequently, when ξ is large, each Dare expects to be investigated with probability ν, and each commits fraud with probability η that decreases with ξ.

FRAUD PREVENTION

So far I have shown in the article (1) it is impossible to separate the two types of agents, and (2) the optimal contract is 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.

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 Theorem 2.

Theorem 2: *When $\eta < 1$ and $\nu > 0$, the amount of fraud is independent of ξ so that, at the margin, fraud prevention has no impact on crime. When $\eta = 1$ and $\nu = 0$, the amount of fraud increases with ξ so that prevention reduces fraud as it reduces ξ.*

This proposition implies that if the moral fiber of the population is weak (i.e., the proportion of Dares is greater than ξ^*) then prevention becomes a waste of scarce resources since fraud prevention is useless. Investment in prevention is useless 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 $\eta = (\frac{\pi}{1-\pi})(\frac{c}{\beta(X)-c})\frac{1}{\xi(X)}$. As $\xi(X)$ increases, η decreases so that the that any one agent commits fraud, given that he is a Dare, decreases when the proportion of Dares in the economy increases. The unconditional probability of fraud in the economy is given by $\eta_u = \eta\xi(X)$, which is the product of the probability that any one Dare commits fraud multiplied by the probability that the agent is a Dare. This product is equal to $\eta_u = (\frac{\pi}{1-\pi})(\frac{c}{\beta(X)-c})$, which is obviously independent of $\xi(X)$. Thus investing in prevention when $\xi \gg \xi^*$ has no impact on the amount of fraud in the economy; it only has an impact on the probability that any one Dare commit fraud, and that impact is positive (i.e., $\frac{\partial\eta_u}{\partial\xi} = 0$ and $\frac{\partial\eta}{\partial\xi} > 0$). This means that the number of fraudulent claims in the economy remains equal to $F = N\pi\eta\xi(X) = N\pi\eta_u$ no matter what the proportion of Dares is, provided it remains greater than ξ^*.

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? To answer this question, it is sufficient to examine what happens when $\xi \leq \xi^*$, and to compare the utility to the case where no investment is made in prevention. The reason we only need to examine the case where $\xi \leq \xi^*$ is that if the proportion of Dares remains greater than ξ^* then the agents' utility remains invariant in ξ. There is therefore no reason to invest in prevention since it is costly and achieves nothing.

When no investment is done, and $\xi > \xi^*$, the Truths' expected utility is given by

$$EU = \pi U\left(Y - \pi\frac{\beta_{\eta\nu}^2}{\beta_{\eta\nu} - c} + \beta_{\eta\nu}\right) + (1-\pi)U\left(Y + W - \pi\frac{\beta_{\eta\nu}^2}{\beta_{\eta\nu} - c}\right), \tag{21}$$

where $\beta_{\eta\nu}$ solves

$$\frac{U'\left(Y - \pi\frac{\beta_{\eta\nu}^2}{\beta_{\eta\nu} - c} + \beta_{\eta\nu}\right)}{\pi U'\left(Y - \pi\frac{\beta_{\eta\nu}^2}{\beta_{\eta\nu} - c} + \beta_{\eta\nu}\right) + (1-\pi)U'\left(Y + W - \pi\frac{\beta_{\eta\nu}^2}{\beta_{\eta\nu} - c}\right)} = \frac{\beta_{\eta\nu}(\beta_{\eta\nu} - 2c)}{(\beta_{\eta\nu} - c)^2}. \tag{22}$$

When investment is made in prevention, the principal's problem is then to find the optimal amount such that it maximizes the Truths' expected utility given by

$$\max_{\beta,x} EU = \pi U(Y + (1-\pi)\beta - \xi(X)(1-\pi)\beta - x) \\ + (1-\pi)U(Y + W - \pi\beta - \xi(X)(1-\pi)\beta - x). \tag{23}$$

In order for prevention to be worth investing in, it must be that the solution to this problem yields a greater expected utility than the solution to the previous problem. With $X = Nx$, the first order conditions that need to hold for prevention to occur are

$$\frac{\partial EU}{\partial \beta} = 0 = \pi U'(Y + (1-\pi)\beta - \xi(X)(1-\pi)\beta - x)[1 - \pi - \xi(X)(1-\pi)] \\ - (1-\pi)U'(Y + W - \pi\beta - \xi(X)(1-\pi)\beta - x)[\pi + \xi(X)(1-\pi)]. \tag{24}$$

$$\frac{\partial EU}{\partial x} = 0 = -\pi U'(Y + (1-\pi)\beta - \xi(X)(1-\pi)\beta - x)[1 + \beta\xi'(X)N(1-\pi)] \\ - (1-\pi)U'(Y + W - \pi\beta - \xi(X)(1-\pi)\beta - x)[1 + \beta\xi'(X)N(1-\pi)]. \tag{25}$$

The solution to this problem is

$$\frac{U'(Y - \pi\beta - \beta\xi(X)(1-\pi) + \beta - x)}{\begin{bmatrix} \pi U'(Y - \pi\beta - \beta\xi(X)(1-\pi) + \beta - x) \\ + (1-\pi)U'(Y + W - \pi\beta - \beta\xi(X)(1-\pi) - x) \end{bmatrix}} = 1 + \xi(X)\left(\frac{1-\pi}{\pi}\right) \tag{26}$$

and

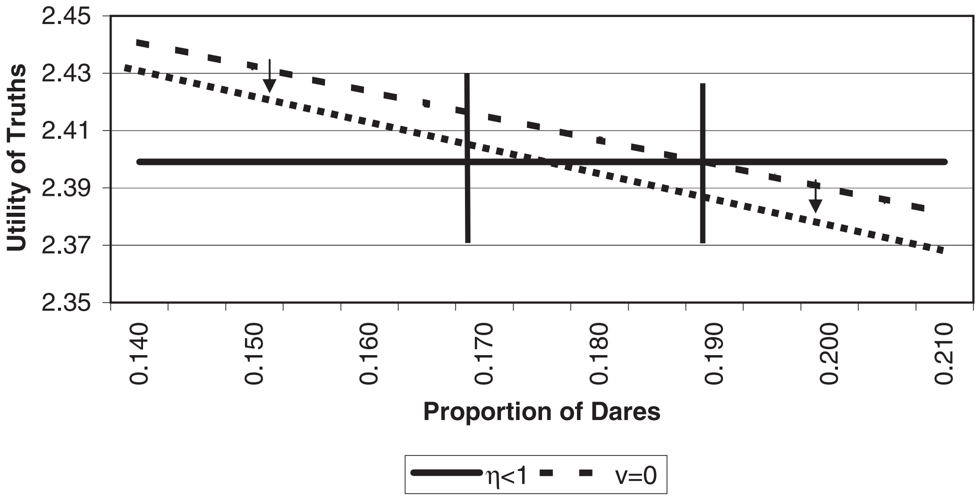
$$-\xi'(X) = \frac{1}{(1-\pi)N\beta}. \tag{27}$$

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 β means that Dares receive more when they commit fraud). As for $\frac{\partial X}{\partial \pi} < 0$, because agents are more likely to have suffered a loss, there is less need to change Dares into Truths since fraud is less likely to be committed. In other words, because fraud occurs in the economy with probability $(\frac{\pi}{1-\pi})(\frac{c}{\beta(X)-c})$, when π increases the amount of fraud decreases. As a result, there is less need to invest in preventing it from happening.

Cost of Prevention

Although the optimal level of prevention may be positive when $\xi < \xi^*$, 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 ξ^*. Figure 7 illustrates what

FIGURE 7
Utility of Truths Given Each Type of Contract: Investment in Prevention



is happening. For prevention to be effective, the proportion of Dares has to be on the downward sloping portion of expected utility curve.[14] 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.

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

$$\begin{bmatrix} \pi U\big(Y + (1-\pi)\beta_x^* - \xi(X)(1-\pi)\beta_x^* - x\big) \\ +(1-\pi)U\big(Y + W - \pi\beta_x^* - \xi(X)(1-\pi)\beta_x^* - x\big) \end{bmatrix} > \begin{bmatrix} \pi U\big(Y - p_{\eta\nu}^* + \beta_{\eta\nu}^*\big) \\ +(1-\pi)U\big(Y + W - p_{\eta\nu}^*\big) \end{bmatrix}. \tag{28}$$

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.

Can Prevention Be Worthless, or Even Worse?

Paradoxically, investment in prevention can also increase fraud. To see why, suppose that the proportion of Dares remains greater than ξ^* after an investment in prevention.

[14] 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 downward.

Because the unconditional probability of fraud is $\eta_u = \eta\xi(X) = (\frac{\pi}{1-\pi})(\frac{c}{\beta(X)-c})$, 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.[15]

Another possibility is that prevention reduces the proportion of Dares below ξ^*. We know at that point that the insurer stops auditing so that a Dare always commits fraud when given the opportunity. This means that the number of fraudulent claims goes from $F(0) = N\pi\eta\xi(0)$ before any investment in fraud prevention to $F(X) = N\pi\xi(X)$ after. The number of fraudulent claims can then increase after an investment in fraud prevention if $\eta\ \xi(0) < \xi(X)$. This occurs when $\beta(0) > (\frac{\pi}{1-\pi})(\frac{c}{\xi(X)}) + c$. We know from Equation (5) that $\beta\ (0) > 2c$. Thus $\xi(X) > \frac{\pi}{1-\pi}$ is a sufficient condition for fraud to increase after investment an prevention has been made. We know that the highest ξ such that no investigation occurs is ξ^*. Thus, $\xi^* > \frac{\pi}{1-\pi}$ is a sufficient condition such that fraud can increase after an investment in prevention.

DYNAMIC CONSIDERATIONS

I assumed in this article 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 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 δ, the sunk cost penalty becomes $k^* = k + \frac{EU^* - EU^A}{\delta} > 0$. As we know from the analysis, however, the sunk cost penalty play no role in determining the optimal contract not the equilibrium behavior of the insured or of the insurer.

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 in the economy ultimately reaches some proportion ξ^*, where it will remain forever when investment in prevention is not possible since I have shown that investigation never occurs when $\xi < \xi^*$. As a result, no more Dare is found to have committed a crime afterwards so that their proportion remains equal to ξ^*.

[15] 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 $\frac{\partial\eta}{\partial X} > 0$.

CONCLUSION

My article 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 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 article follow. 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 show that in the financial market, regulatory violations do not seem to have any impact on a firm's value.[16] 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 multiperiod 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

[16] One possible explanation is that regulatory violations are errors covered under directors' and officers' insurance policies (see Core, 1997; Gutiérrez, 2003).

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.

The model and the conclusions I reached in this article are, of course, driven by the assumptions that I have laid out regarding what players are allowed to do and the constraints they face. For instance, all insurers face the same auditing technology so that the use of a more efficient fraud control technique by one insurer, which would give it a competitive advantage, is not possible. It is therefore clear that my results would apply to the real world only if the myriad of assumptions[17] that I have laid out hold. This is hardly the case in reality.

Similarly, I modeled the behavior of only two players in this fraud game: the principal and the agent. I therefore discarded the presence of important side players involved in fraud rings, such as not-so-honest body shops vendors and chiropractors. The model therefore is only interested in examining one particular aspect of the insurance fraud problem and abstracts from all others. In that sense, the model cannot explain all that goes on with *ex post* moral hazard in insurance. Indeed, no economic model can explain all aspects of economic life. As Robert Solow said soon after receiving his Nobel Prize in economics in 1987: "There is no Economic Theory of Everything, and attempts to construct one seem to merge toward a Theory of Nothing."[18] I present in this article an economic theory of human behavior in presence of *ex post* moral hazard, based on assumptions commonly found in the academic literature, and applied to a very specific context.

I did not study the optimal way to finance prevention in this economy since it is outside the scope of the article. 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 (2001). The poll tax has the advantage of making the analysis easier, but it does not represent reality. In the model, 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 article emphasizes, resistance to fraud is futile and wasteful when the proportion of agents that have a low propensity to tell the truth is high.

APPENDIX: PROOFS

Proof of Proposition 1: The maximization problem for the Truth is

$$\max_{p,\beta} EU = \pi U(Y - p + \beta) + (1 - \pi)U(Y + W - p) \tag{A1}$$

[17] For instance, as one referee argued repeatedly, the model holds only under very specific constraints such as: (1) all insurers must have perfect information about each other's fraud control activities; (2) all insurers must have equal fraud control capacities; (3) all insurers must have identical products, with identical prices, sold in a homogenous market; (4) there must be no friction or delays in adopting new fraud control strategies; and (5) fraudsters must have complete knowledge of all insurers' fraud control methods.

[18] Excerpt from Robert Solow's October 1988 lecture at Trinity University, http://www.trinity.edu/nobel/

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

Proof of Proposition 2: Substituting Equations (1) and (2) into (3) and (4) yields

$$\max_{p,\beta} EU = \pi U(Y - p + \beta) + (1 - \pi)U(Y + W - p) \quad \text{Subject to } p = \pi\frac{\beta^2}{\beta - c}. \tag{A2}$$

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

Proof of Corollary 1: From (1) 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.

Proof of Proposition 3: The complete proof is the same as the proof of Proposition 3 in Picard (1996). I present here the proof for the case where $\eta < 1$ and $\nu > 0$.

Suppose $\eta < 1$ and $\nu > 0$. If a separating contract exist, then the PBNE of the fraud game is such that

$$\eta = \left(\frac{\pi}{1 - \pi}\right)\left(\frac{c}{\beta_D - c}\right) \tag{A3}$$

and

$$\nu = \frac{U(Y + W - p_D + \beta_D) - U(Y + W - p_D)}{U(Y + W - p_D + \beta_D) - U(Y + W - p_D) + k}. \tag{A4}$$

Note that any cross-subsidy between the two types of agents is included in their respective premiums. Substituting (A4) into (9) yields

$$\begin{aligned} &\pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D) \\ &\quad \geq \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T). \end{aligned} \tag{A5}$$

Note that the left hand side of (A5) is equal to the right hand side of (10) so that

$$\begin{aligned} &\pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T) \\ &\quad \geq \pi U(Y - p_T + \beta_T) + (1 - \pi)U(Y + W - p_T + \beta_T). \end{aligned} \tag{A6}$$

This occurs only if $\beta_T = 0$. With $\beta_T = 0$, we must also have $p_T = 0$ from (8) so that (10) becomes

$$\pi U(Y) + (1 - \pi)U(Y + W) \geq \pi U(Y - p_D + \beta_D) + (1 - \pi)U(Y + W - p_D). \tag{A7}$$

Substituting (A4) into (7), we find that

$$\pi U(Y - p_D + \beta_D) + (1-\pi)U(Y + W - p_D) \geq \pi U(Y) + (1-\pi)U(Y + W). \quad \text{(A8)}$$

These two equations hold only if $\beta_D = 0$ and $p_D = 0$. This means that no separating contracts exists when $\eta < 1$ and $\nu > 0$.[19] The remainder of the proof is the same as in Picard (1996). Q.E.D.

Proof of Proposition 4: 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 $\nu > 0$.[20]

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

$$b_1 = 0 \quad \text{(A9)}$$

$$b_2 = 0 \quad \text{(A10)}$$

$$b_3 = \frac{\xi(1-\eta)}{(1-\xi) + \xi(1-\eta)} \quad \text{(A11)}$$

$$b_4 = \frac{1-\xi}{(1-\xi) + \xi(1-\eta)}. \quad \text{(A12)}$$

When a benefit is requested, her beliefs are given as

$$a_1 = \frac{\pi(1-\xi)}{\pi + \xi(1-\pi)\eta} \quad \text{(A13)}$$

$$a_2 = \frac{\pi\xi}{\pi + \xi(1-\pi)\eta} \quad \text{(A14)}$$

$$a_3 = \frac{\xi(1-\pi)\eta}{\pi + \xi(1-\pi)\eta} \quad \text{(A15)}$$

[19] Altenatively, I can also show that (9) and (10) cannot hold at the same time.
[20] 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 $\nu = 0$.

$$a_4 = 0. \tag{A16}$$

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

$$(-c - \beta_{\eta\nu})(1 - a_3) + (-c)a_3 = -\beta_{\eta\nu}, \tag{A17}$$

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 (A15), the probability that a Dare commits a crime is given by[21]

$$\eta = \frac{\pi}{(1-\pi)\xi}\left(\frac{c}{\beta_{\eta\nu} - c}\right). \tag{A18}$$

The principal investigates with probability

$$\nu = \frac{U(Y + W - p_{\eta\nu} + \beta_{\eta\nu}) - U(Y + W - p_{\eta\nu})}{U(Y + W - p_{\eta\nu} + \beta_{\eta\nu}) - U(Y + W - p_{\eta\nu}) + k}. \tag{A19}$$

The beliefs of the principal in each information node are then

$$a_1 = (1 - \xi)\frac{\beta_{\eta\nu} - c}{\beta_{\eta\nu}} \tag{A20}$$

$$a_2 = \xi\frac{\beta_{\eta\nu} - c}{\beta_{\eta\nu}} \tag{A21}$$

$$a_3 = \frac{c}{\beta_{\eta\nu}} \tag{A22}$$

$$a_4 = b_1 = b_2 = 0 \tag{A23}$$

$$b_3 = \frac{\xi(1-\pi)(\beta_{\eta\nu} - c) - c}{(1-\pi)\beta_{\eta\nu} - c} \tag{A24}$$

$$b_4 = \frac{(1-\xi)(1-\pi)(\beta_{\eta\nu} - c)}{(1-\pi)\beta_{\eta\nu} - c}. \tag{A25}$$

Note that for (A24) and (A25) to be between zero and one the proportion of Dares, ξ, must be larger than $\frac{\pi}{1-\pi}(\frac{c}{\beta_{\eta\nu} - c})$. This fraction is the same as the one needed to have $\eta < 1$.

The premium that yields zero-profit is given by

$$p_{\eta\nu} = (1 - \xi)\pi(\beta_{\eta\nu} + c\nu) + \xi[\pi\beta_{\eta\nu} + (1-\pi)\beta_{\eta\nu}\eta(1-\nu) + c\nu[\pi + (1-\pi)\eta]]. \tag{A26}$$

[21] By construction, $\eta < 1$ in this part of the proof construction so that it must be that $\xi > \frac{\pi}{1-\pi}(\frac{c}{\beta - c})$.

The problem faced by the principal is then

$$\max_{p_{\eta\nu},\beta_{\eta\nu}} EU_{\eta\nu} = \pi U(Y - p_{\eta\nu} + \beta_{\eta\nu}) + (1-\pi)U(Y + W - p_{\eta\nu}) \tag{A27}$$

subject to

$$p_{\eta\nu} = (1-\xi)\pi(\beta_{\eta\nu} + c\nu) + \xi[\pi\beta_{\eta\nu} + (1-\pi)\beta_{\eta\nu}\eta(1-\nu) + c\nu[\pi + (1-\pi)\eta]] \tag{A28}$$

$$\eta = \frac{1}{\xi}\left(\frac{\pi}{1-\pi}\right)\left(\frac{c}{\beta_{\eta\nu} - c}\right) \tag{A29}$$

$$\nu = \frac{U(Y + W - p_{\eta\nu} + \beta_{\eta\nu}) - U(Y + W - p_{\eta\nu})}{U(Y + W - p_{\eta\nu} + \beta_{\eta\nu}) - U(Y + W - p_{\eta\nu}) + k}. \tag{A30}$$

Substituting for the PBNE constraints yields

$$\max_{p_{\eta\nu},\beta_{\eta\nu}} EU_{\eta\nu} = \pi U(Y - p_{\eta\nu} + \beta_{\eta\nu}) + (1-\pi)U(Y + W - p_{\eta\nu}) \tag{A31}$$

subject to

$$p_{\eta\nu} = \pi\frac{\beta_{\eta\nu}^2}{\beta_{\eta\nu} - c}. \tag{A32}$$

This maximization problem is exactly the same that the Criminal faces in an economy with full information (see Equation (A2) and Proposition 2). We can therefore say that if $\xi > \bar{\xi} = \frac{\pi}{1-\pi}(\frac{c}{\beta_{\eta\nu} - c})$, 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

$$\max_{p_{0\nu},\beta_{0\nu},\nu_{0\nu}} EU_{0\nu} = \pi U(Y - p_{0\nu} + \beta_{0\nu}) + (1-\pi)U(Y + W - p_{0\nu}) \tag{A33}$$

subject to

$$p_{0\nu} = (1-\xi)\pi\beta_{0\nu} + \xi[\pi\beta_{0\nu} + (1-\pi)\beta_{0\nu}(1-\nu_{0\nu})] + c\nu[\xi + \pi(1-\xi)]. \tag{A34}$$

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

$$\frac{\partial EU_{0\nu}}{\partial p_{0\nu}} = 0 = -[\pi U'(Y - p_{0\nu} + \beta_{0\nu}) + (1-\pi)U'(Y + W - p_{0\nu})] + \lambda_{0\nu} \tag{A35}$$

$$\frac{\partial EU_{0\nu}}{\partial \beta_{0\nu}} = 0 = \pi U'(Y - p_{0\nu} + \beta_{0\nu}) - \lambda_{0\nu}[\pi + \xi(1-\pi)(1-\nu_{0\nu})] \tag{A36}$$

$$\frac{\partial EU_{0\nu}}{\partial \nu_{0\nu}} = 0 = \lambda_{0\nu}[\xi(1-\pi)\beta_{0\nu} - c(\xi + \pi(1-\xi))]. \tag{A37}$$

Solving yields the desired results.

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

$$\max_{p_{00},\beta_{00}} EU_{00} = \pi U(Y - p_{00} + \beta_{00}) + (1-\pi)U(Y + W - p_{00}) \tag{A38}$$

subject to

$$p_{00} = (1-\xi)\pi\beta_{00} + \xi\beta_{00}. \tag{A39}$$

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

$$\frac{\partial EU_{00}}{\partial p_{00}} = 0 = -[\pi U'(Y - p_{00} + \beta_{00}) + (1-\pi)U'(Y + W - p_{00})] + \lambda_{00} \tag{A40}$$

$$\frac{\partial EU_{00}}{\partial \beta_{00}} = 0 = \pi U'(Y - p_{00} + \beta_{00}) - \lambda_{00}[\pi(1-\xi) + \xi]. \tag{A41}$$

Solving yields

$$\frac{U'(Y - p_{00} + \beta_{00})}{\pi U'(Y - p_{00} + \beta_{00}) + (1-\pi)U'(Y + W - p_{00})} = 1 + \xi\frac{1-\pi}{\pi} \tag{A42}$$

which is the desired result. Q.E.D.

Proof of Theorem 1: Define

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

This proof has three parts. First, I will show that $EU_{00} \geq EU_{0\nu}$ for all ξ. 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 $\tilde{\xi} > \bar{\xi} = \frac{\pi}{1-\pi}(\frac{c}{\beta_{\eta\nu} - c})$. Q.E.D.

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

$$EU_{00} - EU_{0\nu} = \begin{bmatrix} \pi U\big(Y - p^*_{00} + \beta^*_{00}\big) + (1-\pi)U\big(Y + W - p^*_{00}\big) \\ -\pi U\big(Y - p^*_{0\nu} + \beta^*_{0\nu}\big) - (1-\pi)U\big(Y + W - p^*_{0\nu}\big) \end{bmatrix} \geq 0 \tag{A43}$$

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

$$\begin{aligned}\frac{\partial(EU_{00} - EU_{0\nu})}{\partial c} &= -\frac{\partial p^*_{00}}{\partial c}\left[\pi U'\left(Y - p^*_{00} + \beta^*_{00}\right) + (1-\pi)U'\left(Y + W - p^*_{00}\right)\right] \\ &\quad + \frac{\partial \beta^*_{00}}{\partial c}\pi U\left(Y - p^*_{00} + \beta^*_{00}\right) - \frac{\partial \beta^*_{0\nu}}{\partial c}\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) \\ &\quad + \frac{\partial p^*_{0\nu}}{\partial c}\left[\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) + (1-\pi)U'\left(Y + W - p^*_{0\nu}\right)\right]. \quad \text{(A44)}\end{aligned}$$

This is continuous for all $c > 0$.

$$\begin{aligned}\frac{\partial(EU_{00} - EU_{0\nu})}{\partial c} &= \frac{\partial p^*_{0\nu}}{\partial c}\left[\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) + (1-\pi)U'\left(Y + W - p^*_{0\nu}\right)\right] \\ &\quad - \frac{\partial \beta^*_{0\nu}}{\partial c}\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right). \quad \text{(A45)}\end{aligned}$$

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 $p^*_{0\nu} = [\pi\ (1-\xi) + \xi] \times \beta^*_{0\nu}$. We also know that $\frac{\partial \beta^*_{0\nu}}{\partial c} = \frac{\xi + (1-\xi)\pi}{\xi(1-\pi)} > 0$ since $\beta^*_{0\nu} = c[\frac{\pi}{(1-\pi)\xi} + 1]$. 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,

$$\begin{aligned}\frac{\partial(EU_{00} - EU_{0\nu})}{\partial c} &= [\pi(1-\xi) + \xi]\frac{\partial \beta^*_{0\nu}}{\partial c}\left[\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) + (1-\pi)U'\left(Y + W - p^*_{0\nu}\right)\right] \\ &\quad - \frac{\partial \beta^*_{0\nu}}{\partial c}\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right). \quad \text{(A46)}\end{aligned}$$

Finding the optimum yields

$$\frac{U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right)}{\pi U'\left(Y - p^*_{0\nu} + \beta^*_{0\nu}\right) + (1-\pi)U'\left(Y + W - p^*_{0\nu}\right)} = 1 + \xi\frac{(1-\pi)}{\pi} \quad \text{(A47)}$$

which is the solution to Proposition 3 (Equation (18)). 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

$$\frac{\partial^2(EU_{00}-EU_{0\nu})}{\partial c^2}$$
$$=-\frac{\partial^2\beta^*_{0\nu}}{\partial c^2}\pi U'\big(Y-p^*_{0\nu}+\beta^*_{0\nu}\big)-\frac{\partial\beta^*_{0\nu}}{\partial c}\left[\frac{\partial\beta^*_{0\nu}}{\partial c}-\frac{\partial p^*_{0\nu}}{\partial c}\right]\pi U'\big(Y-p^*_{0\nu}+\beta^*_{0\nu}\big)$$
$$+\frac{\partial^2 p^*_{0\nu}}{\partial c^2}\big[\pi U'\big(Y-p^*_{0\nu}+\beta^*_{0\nu}\big)+(1-\pi)U'\big(Y+W-p^*_{0\nu}\big)\big]$$
$$+\frac{\partial p^*_{0\nu}}{\partial c}\left[\pi\left[\frac{\partial\beta^*_{0\nu}}{\partial c}-\frac{\partial p^*_{0\nu}}{\partial c}\right]U'\big(Y-p^*_{0\nu}+\beta^*_{0\nu}\big)-(1-\pi)\frac{\partial p^*_{0\nu}}{\partial c}U'\big(Y+W-p^*_{0\nu}\big)\right]. \tag{A48}$$

Since $\frac{\partial^2 p^*_{0\nu}}{\partial c^2}=\frac{\partial^2\beta^*_{0\nu}}{\partial c^2}=0$, we have

$$\frac{\partial^2(EU_{00}-EU_{0\nu})}{\partial c^2}=-\left(\frac{\partial\beta^*_{0\nu}}{\partial c}-\frac{\partial p^*_{0\nu}}{\partial c}\right)^2\pi U''\big(Y-p^*_{0\nu}+\beta^*_{0\nu}\big)$$
$$-\left(\frac{\partial p^*_{0\nu}}{\partial c}\right)^2(1-\pi)U''\big(Y+W-p^*_{0\nu}\big)>0, \tag{A49}$$

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

$$\frac{U'\big(Y-p^*_{0\nu}+\beta^*_{0\nu}\big)}{\pi U'\big(Y-p^*_{0\nu}+\beta^*_{0\nu}\big)+(1-\pi)U'\big(Y+W-p^*_{0\nu}\big)}=1+\xi\frac{(1-\pi)}{\pi} \tag{A50}$$

which is where $\nu=0$.

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

$$EU_{00}-EU_{\eta\nu}=\begin{bmatrix}\pi U\big(Y-p^*_{00}+\beta^*_{00}\big)+(1-\pi)U\big(Y+W-p^*_{00}\big)\\-\pi U\big(Y-p^*_{\eta\nu}+\beta^*_{\eta\nu}\big)-(1-\pi)U\big(Y+W-p^*_{\eta\nu}\big)\end{bmatrix}\ge 0 \tag{A51}$$

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

$$EU_{00}-EU_{\eta\nu}=\begin{bmatrix}\pi U\big(Y-p^*_{00}+\beta^*_{00}\big)+(1-\pi)U\big(Y+W-p^*_{00}\big)\\-\pi U\big(Y-p^*_{\eta\nu}+\beta^*_{\eta\nu}\big)-(1-\pi)U\big(Y+W-p^*_{\eta\nu}\big)\end{bmatrix}\le 0. \tag{A52}$$

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

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

$$\begin{aligned}\frac{\partial(EU_{00} - EU_{\eta\nu})}{\partial\xi} \\ &= \pi U'\left(Y - p^*_{00} + \beta^*_{00}\right)\left[\frac{\partial\beta^*_{00}}{\partial\xi} - \frac{\partial p^*_{00}}{\partial\xi}\right] + (1-\pi)U'\left(Y + W - p^*_{00}\right)\left[-\frac{\partial p^*_{00}}{\partial\xi}\right] \\ &\quad - \pi U'\left(Y - p^*_{\eta\nu} + \beta^*_{\eta\nu}\right)\left[\frac{\partial\beta^*_{\eta\nu}}{\partial\xi} - \frac{\partial p^*_{\eta\nu}}{\partial\xi}\right] - (1-\pi)U'\left(Y + W - p^*_{\eta\nu}\right)\left[-\frac{\partial p^*_{\eta\nu}}{\partial\xi}\right].\end{aligned} \tag{A53}$$

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 $p^*_{00} = [\pi\ (1-\xi) + \xi]\ \beta^*_{00}$, and β^*_{00} solves

$$\begin{aligned}&\frac{U'\left(Y - [\pi(1-\xi)+\xi]\beta^*_{00} + \beta^*_{00}\right)}{\pi U'\left(Y - [\pi(1-\xi)+\xi]\beta^*_{00} + \beta^*_{00}\right) + (1-\pi)U'\left(Y + W - [\pi(1-\xi)+\xi]\beta^*_{00}\right)} \\ &\quad = 1 + \xi\frac{1-\pi}{\pi}.\end{aligned} \tag{A54}$$

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

$$0 \geq \pi U\left(Y - p^*_{00} + \beta^*_{00}\right)\left[\frac{\partial\beta^*_{00}}{\partial\xi} - \frac{\partial p^*_{00}}{\partial\xi}\right] + (1-\pi)U\left(Y + W - p^*_{00}\right)\left[-\frac{\partial p^*_{00}}{\partial\xi}\right]$$

and

$$\frac{\partial\beta^*_{00}}{\partial\xi} \leq \frac{\beta^*_{00}}{1 + \xi\dfrac{1-\pi}{\pi}} \tag{A55}$$

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 $\tilde{\xi} > \bar{\xi} = \frac{\pi}{1-\pi}(\frac{c}{\beta_{\eta\nu} - c})$. 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 ξ, 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 $\xi = \bar{\xi}$. Q.E.D.

Proof of Theorem 2: I divide this proof into two parts.

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

$$E(\eta) = \eta = \left(\frac{\pi}{1-\pi}\right)\left(\frac{c}{\beta - c}\right). \tag{A56}$$

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

$$E(\eta/D) = \frac{\pi}{(1-\pi)\xi}\left(\frac{c}{\beta - c}\right). \tag{A57}$$

When I include the fact that the probability that a contract is bought by a criminal is given by ξ, the probability that a fraudulent claim is filed becomes

$$E(\eta) = \xi\frac{\pi}{(1-\pi)\xi}\left(\frac{c}{\beta - c}\right) = \eta. \tag{A58}$$

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,

$$\nu = \frac{U(Y+W-p+\beta) - U(Y+W-p)}{U(Y+W-p+\beta) - U(Y+W-p) + k} \tag{A59}$$

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

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

REFERENCES

Becker, G. S. S., 1968, Crime and Punishment: An Economic Approach, *Journal of Political Economy*, 46: 169–217.

Besanko, D., and D. F. Spulber, 1989, Delegated Law Enforcement and Noncooperative Behavior, *Journal of Law, Economics and Organizations*, 5: 25–52.

Bond, E. W., and K. J.Crocker, 1997, Hardball and the Soft Touch: The Economics of Optimal Insurance Contracts with Costly State Verification and Endogenous Monitoring, *Journal of Public Economics*, 63: 239–254.

Boyer, M. M., 2001, Mitigating Insurance Fraud: Lump-Sum Awards, Premium Subsidies, and Indemnity Taxes, *Journal of Risk and Insurance*, 68: 403–436.

Boyer, M. M., 2003, Contracting under Ex post Moral Hazard, Costly Auditing and Principal Non-Commitment, *Review of Economic Design*, 8: 1–38.

Boyer, M. M., 2004, Overcompensation as a Partial Solution to Commitment and Renegotiation Problems: The Case of Ex-post Moral Hazard, *Journal of Risk and Insurance*, 71: 559–582.

Caron, L., and G. Dionne, 1997, Insurance Fraud Estimation: More Evidence from the Quebec Automobile Insurance Industry, *Assurances*, 64: 567–578.

Core, J. E., 1997, On the Corporate Demand for Directors' and Officers' Insurance, *Journal of Risk and Insurance*, 64: 63–87.

Dionne, G., and R. Gagné, 2002, Replacement Cost Endorsement and Opportunistic Fraud in Automobile Insurance, *Journal of Risk and Uncertainty*, 24: 213–230.

Ehrlich, I., 1973, Participation in Illegitimate Activities: A Theoretical and Empirical Investigation, *Journal of Political Economy*, 81: 521–565.

Freeman, R. B., 1996, Why Do So Many Young Americans Men Commit Crimes and What Might We Do About It?, *Journal of Economic Perspectives*, 10: 25–42.

Friedman, D., 1999, Why Not Hang Them All: The Virtues of Inefficient Punishment, *Journal of Political Economy*, 107: 259–269 (supplement).

Graetz, M. J., J. F. Reinganum, and L. L. Wilde, 1986, The Tax-Compliance Game: Toward an Interactive Theory of Law Enforcement, *Journal of Law, Economics and Organization*, 2: 1–32.

Grogger, J., 1995, The Effect of Arrests on the Employment and Earnings of Young Men, *Quarterly Journal of Economics*, 110: 51–71.

Gutiérrez, M., 2003, An Economic Analysis of Corporate Directors' Fiduciary Duties, *Rand Journal of Economics*, 34: 516–535.

Jost, P. J., 1997, Monitoring, Appeal, and Investigations: The Enforcement and Legal Process, *Journal of Regulatory Economics*, 12: 127–146.

Jost, P. J., 2001, Crime, Coordination, and Punishment: An Economic Analysis, *International Review of Law and Economics*, 21: 23–46.

Karpoff, J. M., and J. R. Lott Jr., 1993, The Reputational Penalty Firms Bear From Committing Criminal Fraud, *Journal of Law and Economics*, 36: 757–802.

Khalil, F., 1997, Auditing without Commitment, *Rand Journal of Economics*, 28: 629–640.

Levitt, S. D., 1996, The Effect of Prison Population Size on Crime Rates: Evidence from Prison Overcrowding Litigation, *Quarterly Journal of Economics*, 111: 319–351.

Levitt, S. D., 1997, Incentive Compatibility Constraints as an Explanation for the Use of Prison Sentences Instead of Fines, *International Review of Law and Economics*, 17: 179–192.

Mookherjee, D., and I. Png, 1989, Optimal Auditing, Insurance and Redistribution, *Quarterly Journal of Economics*, 104: 205–228.

Picard, P., 1996, Auditing Claims in the Insurance Market with Fraud: The Credibility Issue, *Journal of Public Economics*, 63: 27–56.

Reinganum, J. F., 2000, Sentencing Guidelines, Judicial Errors and Plea Bargaining, *Rand Journal of Economics*, 31: 62–81.

Reinganum, J. F., and L. L. Wilde, 1985, Income Tax Compliance in a Principal-Agent Framework, *Journal of Public Economics*, 26: 1–18.

Saha, A., and G. Poole, 2000, The Economics of Crime and Punishment: An Analysis of Optimal Penalty, *Economic Letters*, 68: 191–196.

Sanchez, I., and J. Sobel, 1993, Hierarchical Design and Enforcement of Income Tax Policies, *Journal of Public Economics*, 50: 345–369.

Scientific American, 2001, Why Do Prisons Grow, 285(5): 28.

Shavel, S., 1991, Specific Versus General Enforcement of Law, *Journal of Political Economy*, 99: 1088–1108.

Stigler, G. J., 1970, The Optimum Enforcement Laws, *Journal of Political Economy*, 78: 526–536.

Townsend, R. M., 1979, Optimal Contracts and Competitive Markets with Costly State Verification, *Journal of Economic Theory*, 21: 265–293.

Waldfogel, J., 1993, Criminal Sentences as Endogenous Taxes: Are They "Just" or "Efficient," *Journal of Law and Economics*, 36: 139–151.

Waldfogel, J., 1994, The Effect of Criminal Conviction on Income and the Trust "Reposed in the Workmen," *Journal of Human Ressources*, 29: 62–81.

Weisberg, H. I., and R. A. Derrig, 1991, Fraud and Automobile Insurance: A Report on Bodily Injury Liability Claims in Massachussetts, *Journal of Insurance Regulation*, 9: 497–541.