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Two simple models of insurance fraud

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Two simple models of insurance fraud

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Abstract

We show a simple approach to modelling insurance frauds, both ex-ante (with respect to the insured event), in the form of false accidents and staged events, and ex-post, in the form of inflated bills and buildups. Optimal amounts of (under)coverage and excess claims are obtained from the maximizing behavior of policyholders under perfect competition and fraud detection activity by the insurance companies. In both cases, the effect of frauds is to reduce insurance coverage and increase competitive premiums. Numerical results are calculated using plausible parameter assumptions.

JEL code: G22; D81
Keywords: Insurance; fraud; ex-ante moral hazard; ex-post moral hazard; expected utility

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1. Introduction

As a general definition, insurance fraud is any act committed with the intent to obtain undue (monetary) utility from an insurance process. It could benefit the insured, e.g. by means of an overblown compensation, or the insurer, who, for example, could treacherously deny a due benefit, or any other mediator (agent, broker, adjuster, mechanic) involved.

If Consumer Protection Regulations and Institutions, in many countries, have established a well-defined system to deal with the insurer's or agent's attempts to fraud, no special public arrangement is in place to protect the system from the other forms of insurance fraud.

Their relevance, however, is unquestioned. Estimates for the US insurance market quantify the overall damage due to insurance fraud at $ 80 billion per year (Coalition Against Insurance Fraud, 2006). If it were a legitimate corporation, it would rank in the US top 20 in annual revenue.

In Europe, recent estimates quantify in € 13 billion the amount of fraud during 2017, of which less than 20% (€ 2.5 billion) were detected by the insurance companies (Insurance Europe, 2019).

If we consider UK data (Association of British Insurers, 2018), thanks to an intensified crackdown on fraud, the number of uncovered dishonest claims dropped in six years from 139 000 to 113 000, even if the value increased from £ 1 to 1.3 billion. Over 60% of insurance fraud value was in the motor insurance sector.

Including also deceitful applications, a total of 562 000 insurance frauds were detected in 2017: "one scam every minute", with saving for honest customers representing about 6% of all claims.

According to the Association of British Insurers (ABI), almost £ 2 billion of frauds go undetected each year (Insurance Europe, 2013) notwithstanding the important effort in anti-fraud initiatives (the Insurance Fraud Bureau, created in 2006, and the special police unit Insurance Fraud Enforcement Department and the big database Insurance Fraud Register both launched in 2012). The ABI estimates that fraud adds, on average, an extra £ 50 a year to the annual insurance bill for every UK policyholder.

Italy is another country particularly exposed to fraud, especially in the Motor Third Party Liability sector. According to the annual survey by the supervisory Authority (IVASS), in 2018 about 630 000 claims were detected as "exposed to fraud" (23% of total claims), one half of them (13% of total claims) were audited by internal SIU (Special investigation units) and about 56 000 claims were rejected as scams, even if less than 5 000 were taken to court for charges of fraud. The estimated amount of savings due to detected frauds reached in 2018 the value of 253 million euros, representing almost 2% of total gross premiums (IVASS, 2020).

Insurance frauds are the realm of intense creativity: they can be committed before underwriting the contract (fake information, identity theft, misreports) or after the policy has been issued. In the first case, they often have to do with risk classification and adverse selection, to obtain favorable policy conditions (premium leakage); in the second case, they pertain to moral hazard, ex-ante or ex-post with respect to the accident.

In fact, the most common fraud methods are the following two:

1) false accidents (thefts, fires, crashes, etc.), in the form of ghost, induced or staged events (e.g. the so-called crash-for-cash)[1];

2) inflated bills (both high fees for standard procedures or bills for services never provided or undue).

According to a Swedish research (Insurance Europe, 2013), 80-90% of all fraudulent claims are of the second type.

The aim of this paper is to model both types of frauds through a simple approach, showing, from standard optimizing behavior, the effects of frauds on prices and coverage. Differently from previous approaches (see Picard, 2013 for a recent survey), the focus is neither on the optimal auditing function by the insurer nor on the cost function of state falsification by the policyholder but on the optimal amount of ex-ante coverage and ex-post claim in the presence of fraudulent behavior on the demand side and perfect competition on the supply side. In both cases, the effect of frauds is to reduce insurance coverage and increase competitive premiums by amounts which can be numerically evaluated.

2. Ex-ante moral hazard: false accident

We want to single out the case of a staged event set up by a policyholder.

To keep things extremely simple, let the accident be a random variable generating a fixed loss L with probability p_L and 0 otherwise.

The probability p_L and L are common knowledge but the actual occurrence of the accident is only known (without costs) to the insured but not to the insurer. In case of accident, a claim is filed; in the absence of any

[1] One of the famous sarcastic epigrams composed by the Roman poet Marco Valerio Marziale (38-104 A.D.) is just about a fire fraud (Shelton, 1988, p.65):
Empta domus fuerat tibi, Tongiliane, ducentis:
Abstulit hanc nimium casus in urbe frequens.
Conlatum est deciens. Rogo, non potes ipse videri
Incendisse tuam, Tongiliane, domum? (Epigrams, Book III, 52)

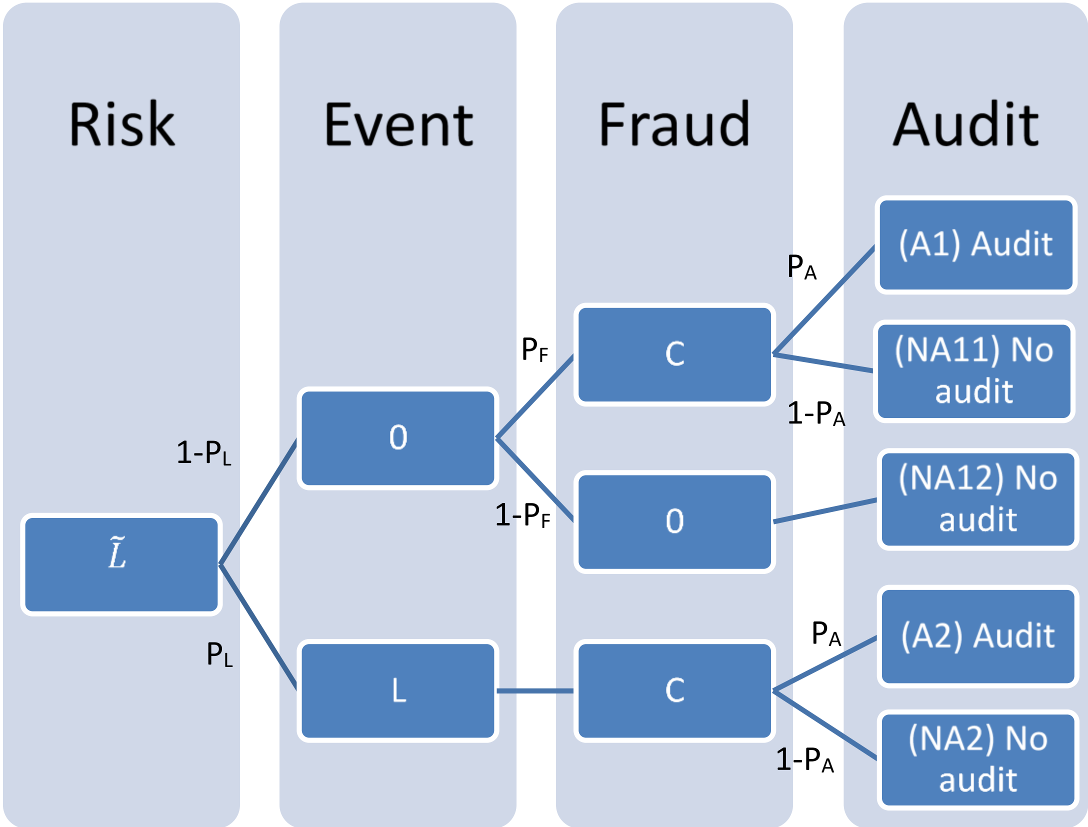
"Tongilianus, you paid two hundred for your house;
An accident too common in this city destroyed it.
You collected ten times more. Doesn't it seem, I pray,
That you set fire to your own house, Tongilianus?"

accident, the insured could behave honestly, with probability 1-p_F, or claim a false loss, with probability p_F. The insurer, in turn, has the alternative to pay off the claim C or trigger a detection process, with probability p_A. This audit is costly for the insurer but, in case of fraud, it can correctly detect the fraud.

In the face of a claim raised by the insured, the uncertainty is about the actual occurrence of the event. In fact, ex-ante, the insurance company is not able to distinguish between the reported claims, therefore it could make both kinds of errors: auditing a good claim (false positive: type 1 error) and not auditing a false claim (false negative: type 2 error).

The sequential game is depicted in Fig. 1.

FIG. 1 Set up of the ex-ante fraud-audit game



The insured's maximizing behavior is represented by two decision variables, the fraud frequency p_F and the percentage coverage:

$$\max_{p_F,\gamma} \mathcal{L} \equiv (1-p_L)U(V^{-1}[p_F p_A V(W_0-\pi-H)+p_F(1-p_A)V(W_0-\pi+\gamma L)+(1-p_F)V(W_0-\pi)]) + p_L U(W_0-\pi-L+\gamma L)$$

[2.1]

where γ, between 0 and 1, is the chosen percentage coverage[2], C≡γL, π is the premium paid, W_0 is the initial individual wealth, and U, V are von Neumann - Morgenstern utility functions representing consumer risk preferences (in general, increasing, concave and increasing, convex respectively). The second utility

[2] By law, the policy coverage C=γL cannot exceed the known maximum loss L.

represents behavior in the fraud game[3]; the first one behavior in the insurance decision[4]. More precisely, the meaning is the following:

a) in case of no accident (probability 1-p_L) the insured can make a fraud (with probability p_F) filing for a claim in the absence of any loss and this claim could be audited or not. In the first case (A1 in Fig. 1) the fraud is detected, the claim is canceled and a lump-sum fraud cost H is applied, representing the monetary equivalent of getting a long-lasting red flag in the insurers rating databases. In case of no auditing (NA1), the false claim is paid off;

b) in the case of accident (probability p_L) the insured suffers a loss L , files for damages and this claim could be audited (A2) or not (NA2).

In this model, the fraud behavior is nested into the bigger problem of insurance: the expected utility of the fraud (in square brackets) is expressed in certainty monetary equivalent and evaluated as the "no loss" side of the insurance alternative. For U=V, p_F=0=H, we have the textbook standard model with optimal full insurance $\gamma^*=1$ (e.g. Varian, 1992, p.180).

The probability p_F could be interpreted as the conditional probability of filing a claim given that no accident has occurred; $p_F(1-p_A)$ is the (conditional) probability of a successful fraud[5].

Note that if $-p_AH+(1-p_A)C<0$ or $p_A > \frac{C}{C+H}$ the fraud game is unfair and it requires a risk loving behavior.

If, instead, the fraud game is favorable (e.g. H=0) even a risk averter could be induced to try a fraud.

In general, p_F is endogenous, chosen optimally, along with γ, in the maximizing behavior of [2.1] by the insured.

At the same time, the audit probability p_A could be optimally chosen, in order to maximize the efficiency of the detection process. This has a "gain" when a fraud is detected, at cost K, and two "costs", when a right claim is uselessly detected (false positive) and when a false claim is undetected (false negative).

A plausible assumption is that p_A is an increasing function of the coverage[6] C, which is known to the insurer:

$$p'_A \equiv \frac{\partial p_A}{\partial C} > 0 \qquad [2.2]$$

the higher the coverage, the lower the probability that a scam is paid out unaudited.

[3] The treatment of fraud as a game is in line with Gary Becker's (1968) simple model of rational crime.

[4] For a classical reference, rationalizing game and insurance, see Friedman and Savage (1948) and the criticisms in Markowitz (1952).

[5] If T is a fraud attempt and NA is non-detection we have: 1-p(T,NA)=1-p(T) + p(T)(1-p(NA |T)). If a fraud is always attempted, then p_F =p(T)=1.

[6] Mookherjee and Png (1989) show the optimality of a random auditing policy and Fagart and Picard (1999) provide conditions under which the audit probability (with a perfect assessment of the loss) is an increasing function of the size of the claim. For a survey of audit strategies and anti-fraud red flag signaling systems, see Dionne, Giuliano and Picard (2009).

Under perfect competition among insurers, the zero-profit condition defines the premium:

$$(1-p_L)[p_F p_A(\pi-K)+p_F(1-p_A)(\pi-C)+(1-p_F)\pi]+p_L[p_A(\pi-C-K)+(1-p_A)(\pi-C)]=0 \tag{2.3}$$

so that:

$$\pi^*=[p_L+(1-p_L)p_F(1-p_A)]C+[(1-p_L)p_F+p_L]\,p_A K\;\equiv p^*C+g^*K>\;p_L C \tag{2.4}$$

and, taking the total derivative we obtain an ordinary differential equation:

$$p_A'=\frac{p_L+(1-p_L)p_F(1-p_A)}{p_F(1-p_L)C-[p_L+(1-p_L)p_F]K}>0 \tag{2.5}$$

where the denominator is assumed positive (and greater than 1) so that $p_A' > 0$.

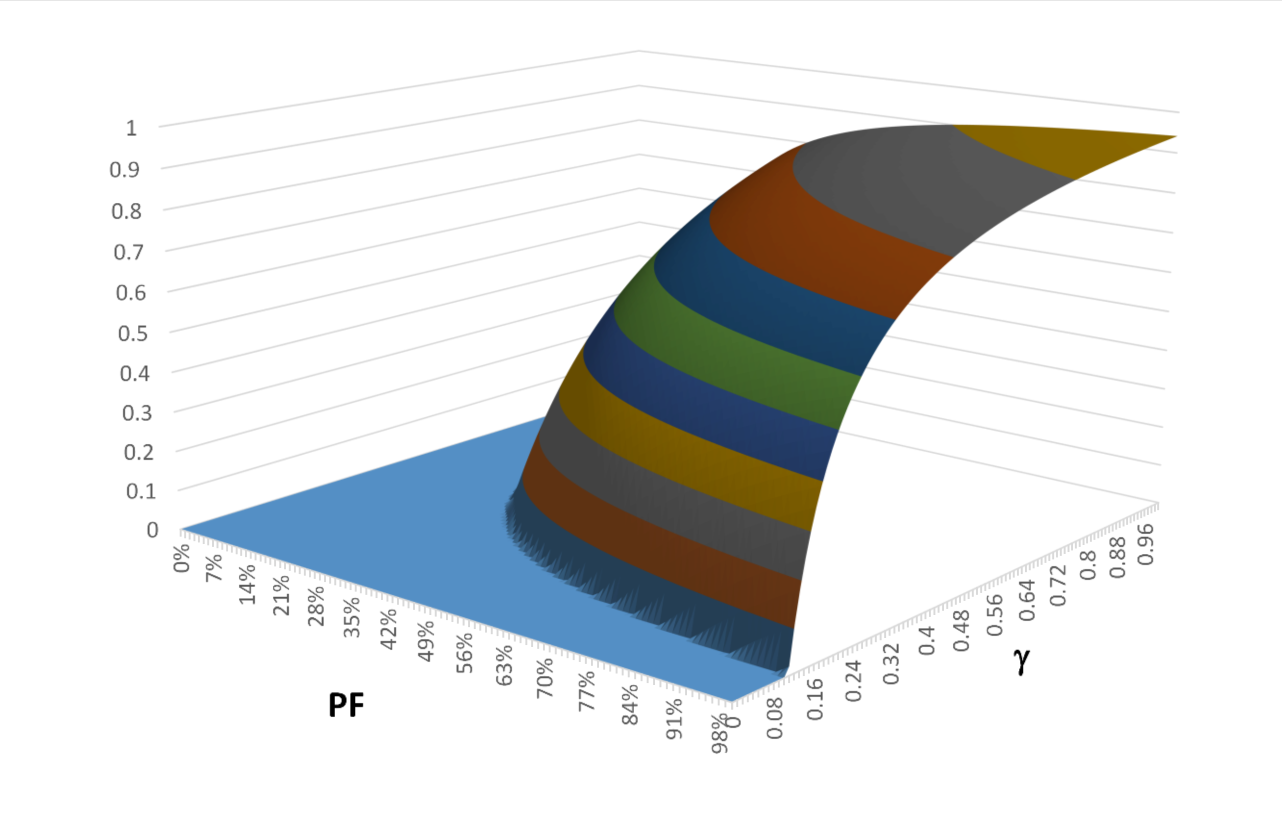
The solution is found to be:

$$p_A\;=\frac{[p_L+(1-p_L)p_F]}{[(1-p_L)p_F]}\left[\frac{p_F(1-p_L)C-[p_L+(1-p_L)p_F]K-1}{p_F(1-p_L)C-[p_L+(1-p_L)p_F]K}\right] \tag{2.6}$$

for $C\geq\frac{[p_L+(1-p_L)p_F]K+1}{p_F(1-p_L)}$ and zero otherwise (see Fig. 2).

It can be seen as an optimal response function by the insurer on the basis of the chosen coverage γ and fraud probability p_F by the insured.

FIG. 2 Audit probability as a function of coverage γ and p_F, with K=0.5 and p_L=5%.



Let us consider the simpler case with a given probability of fraud p_F and uniform risk aversion U=V. The first-order condition (FOC) for the maximum is:

$$FOC: \ \frac{\partial \mathcal{L}}{\partial C} =$$

$$-(1-p_L)p_F p_A p^* U'(W_0 - \pi^* - H) + (1-p_L)p_F(1-p_A)(1-p^*)U'(W_0 - \pi^* + C)$$
$$-(1-p_L)(1-p_F)p^* U'(W_0 - \pi^*) + p_L(1-p^*)U'(W_0 - \pi^* - L + C) = 0 \qquad [2.7]$$

It is easy to show that:

i) the second-order condition (SOC) for a maximum is satisfied (by the concavity of U) being:

$$\frac{\partial^2 \mathcal{L}}{\partial \gamma^2} < 0$$

ii) the extreme values γ=0 and γ=1 are non-optimal and in particular:

$$\frac{\partial \mathcal{L}}{\partial \gamma}_{|\gamma=0} > 0 \quad \text{for H sufficiently small (the Lagrangian is increasing)}$$

$$\frac{\partial \mathcal{L}}{\partial \gamma}_{|\gamma=1} < 0 \quad \text{(the Lagrangian is decreasing)}$$

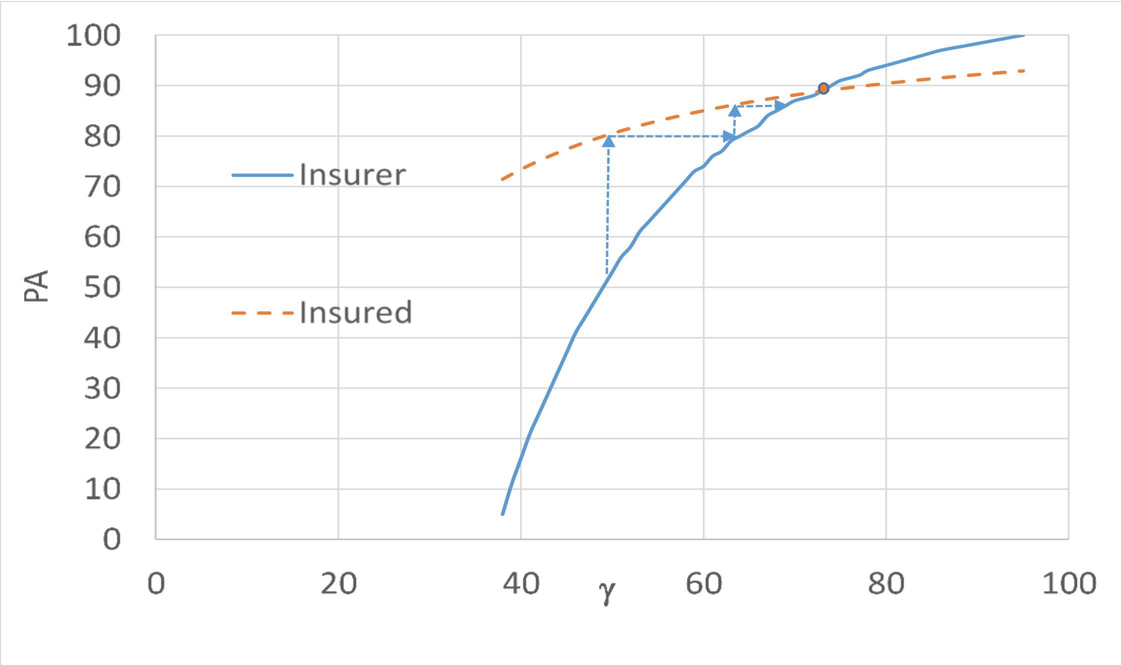
iii) for H sufficiently small, the optimal value γ^* is an interior point $0 < \gamma^* < 1$ with $\frac{\partial \mathcal{L}}{\partial \gamma}_{|\gamma=\gamma^*} = 0$

iv) if p_A is low and p_F is high, the price of the coverage tends to increase and in the limit the demand for insurance would be wiped out; if p_A goes to 1 then γ^* is between 1-H/L (if p_F=1) and 1 (if p_F=0).

Therefore, with ex-ante fraud, we obtain, as a general rule, a higher competitive unit premium p* (>p_L) and a lower optimal coverage γ^*<1 (underinsurance).

For a given p_F, the optimal coverage γ^* is a function of the audit policy of the insurer p_A. In the case of (negative) exponential utility U(x)= - exp(-0.5 x) with ARA=0.5 and p_F=100%, the two reaction function $\gamma^*(p_A)$ and $p_A(\gamma)$ are shown in Fig. 3. By monotone convexity, they have a single equilibrium point which is stable, in the sense that it is reached from any starting decisions for γ (by the insured) and p_A (by the insurance company). In the considered numerical case we obtain γ^*≅72% and p_A≅88% whilst a reduction of p_F to 40% gives γ^*≅74% and p_A≅69% showing that reducing frauds increases the optimal coverage.

FIG. 3 Insurer and insured reaction functions with p_F=100% and ARA=0.5



3. Ex-post moral hazard: inflated bills

In case of ex-post moral hazard, the fraud is attempted once the accident has occurred. The random loss L is covered by a policy at the level γL, $0<\gamma\leq 1$, but the fraudster files for a claim $m\gamma L$ in excess of the right coverage by the "inflation" parameter $m>1$.

The accident has a probability of p_L and the loss L is now a positive random variable with (conditional) density f_L and mean E(L).

The accident occurrence, the probability p_L, the coverage γ and the density f_L are common knowledge but the effective loss amount L is known (without costs) only to the insured.

The optimal solution is obtained as:

$$\max_{p_F,\gamma,\mathrm{m}} \mathcal{L} \equiv (1-p_L)U(W_0-\pi) + p_L U\big(V^{-1}\big[p_F[p_A \int_0^\infty V(W_0-\pi-L+\gamma L-h) f_L dL + (1-p_A)\int_0^\infty V(W_0-\pi-L+m\gamma L) f_L dL] + (1-p_F)[p_A \int_0^\infty V(W_0-\pi-L+\gamma L) f_L dL + (1-p_A)\int_0^\infty V(W_0-\pi-L+\gamma L) f_L dL]\big]\big) \qquad [3.1]$$

The meaning is the following:

a) in case of no accident (with probability $1-p_L$) just the premium π is paid by the policyholder;

b) in case of accident: with probability p_F a fraud is attempted by reporting a loss of mL>L and filing for an inflated claim of $m\gamma L$; this scam is audited with probability p_A and in this case a "reputation cost" of h is set to the fraudster, reducing the received indemnity; otherwise, the inflated bill is paid; with probability $1-p_F$, instead, the fraud is not attempted but, once again, the (costly) audit could be uselessly called for by the insurer.

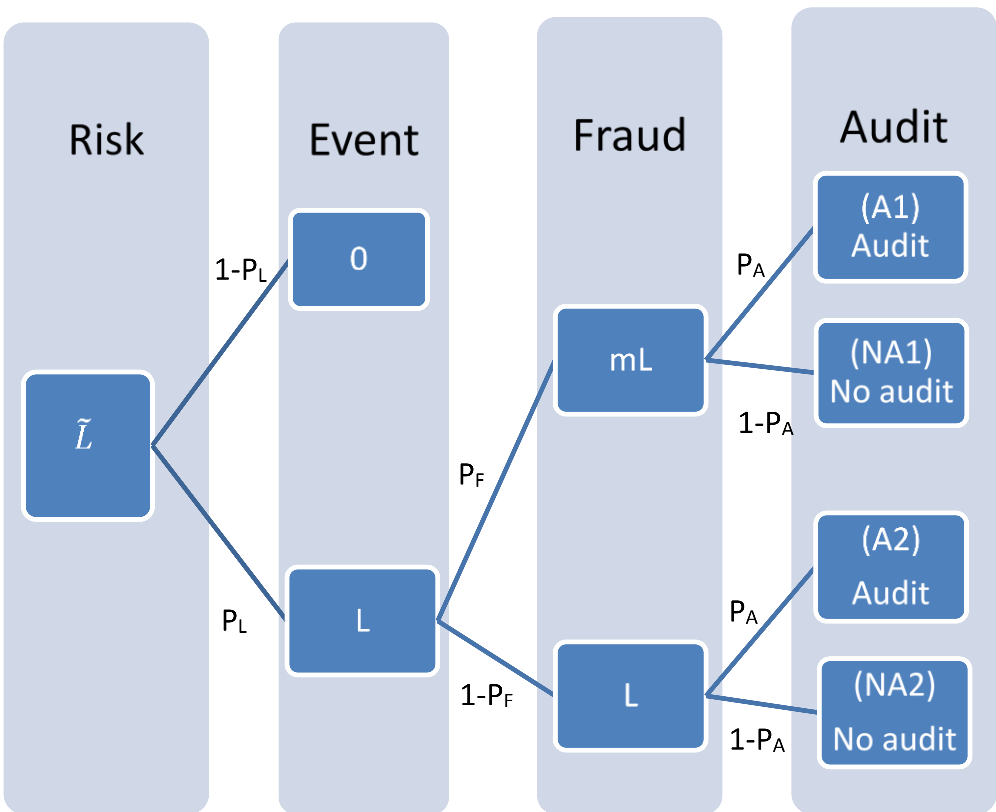
By assumption, at the fixed cost k, the audit can discriminate between false and correct claims.

As before, if $(1-p_A)(m-1)\gamma E(L)-p_A h<0$ or $p_A > \frac{(m-1)\gamma E(L)}{h+(m-1)\gamma E(L)}$ the fraud game is unfair and it requires a risk loving behavior.

If, instead, the fraud game is favorable (e.g. h=0) even a risk averter could be induced to try a fraud.

The sequential game of the ex-post moral hazard is depicted in Fig. 2.

FIG. 2 Set up of the ex-post fraud-audit game



From perfect competition, the zero-profit condition applies:

$$(1-p_L)\pi + p_L\left[p_F\,p_A\int_0^{\infty}(\pi - L - K)f_L dL + \ p_F(1-p_A)\int_0^{\infty}(\pi - m\gamma L)f_L dL\right]$$

$$+p_L\left[\,(1-p_F)\,p_A\int_0^{\infty}(\pi-\gamma L-K)f_L dL + (1-\ p_F)(1-p_A)\int_0^{\infty}(\pi-\gamma L)f_L dL\,\right] = 0 \qquad [3.2]$$

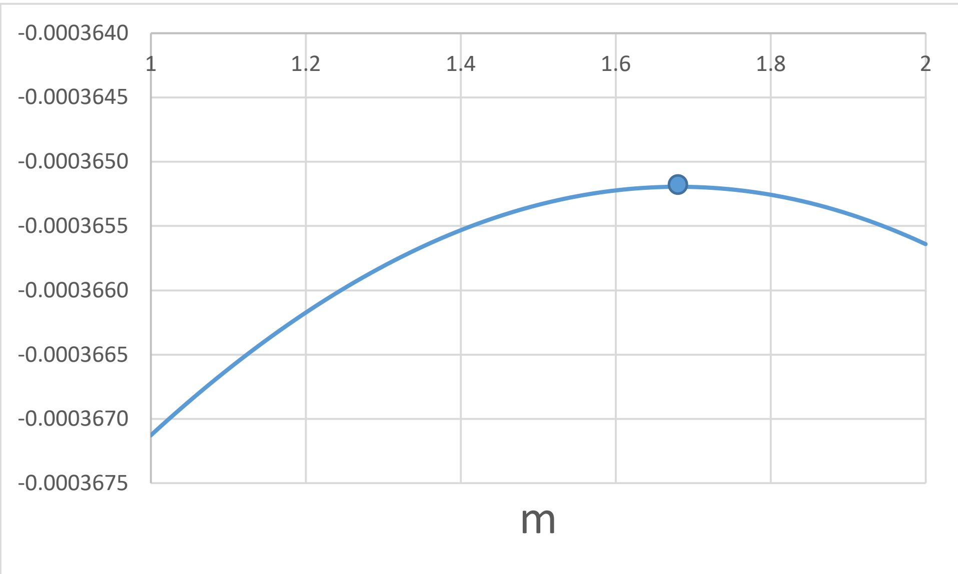
so that:

$$\pi^* = p_L[1 + p_F(1-p_A)(m-1)]\gamma E(L) + p_L p_A K \ \ > \ p_L\gamma E(L) \qquad [3.3]$$

The standard case $\pi = p_L\gamma E(L)$ is obtained in the absence of fraud activity.

As an example (Fig. 2) we consider the case of U negative exponential ($-e^{-A_U x}$) and V exponential ($e^{A_V x}$) utilities, with risk coefficients A_U=0.8 and A_V=0.3 respectively, gamma distribution for L, with parameters α=2, β=1 >0, and expected loss E(L)=α/β=2, p_L=5%, p_F=80%, p_A=20%, W_0=10, h=0.5, k=0.5. For γ=0.8 the optimal buildup is m*=1.68 and the premium is 50% higher than the no-fraud case (Fig. 2).

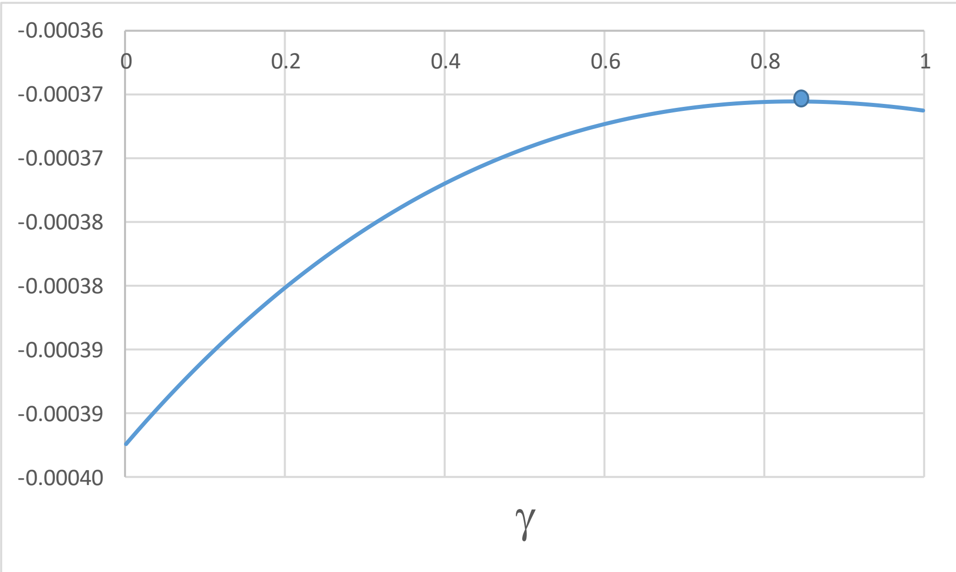
FIG. 2 Optimal buildup with exponential utility



In the case of full insurance (γ=1) the optimal buildup is m*=1.16 and the premium is 15% higher than the no-fraud case.

If m is known, m=1.40, the optimal coverage is γ*=0.84 and the premium is 32% higher than the no-fraud case (Fig. 3)

FIG. 3 Optimal coverage with buildup and exponential utility



Clearly, different models can be easily analyzed, in the given setup, assuming different risk preferences (e.g. decreasing absolute risk aversion) and different loss distributions.

4. Conclusions

Insurance fraud is a worrisome, widespread and increasing phenomenon in many countries. Treating fraud as a criminal game we have shown that it is possible to include ex-ante and ex-post moral hazard in the classical setup of optimal insurance decisions. Both false events (fraud in absence of accident) and inflated bills (fraud after the accident) are considered analytically and numerically, obtaining manageable models and plausible results.

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