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GAME THEORY TO ASSESS EXPERT SYSTEM NEED FOR INTERNAL AUDIT

A firm's in-house audit can assist management in maintaining adequate internal controls and help inform external auditors about the reliability of financial statements [2; 3; 4; 5]. In this paper we present a game theoretic model that may help a firm decide on audit strategies and determine whether to improve internal audit quality by implementing an expert system that generates automatic alerts in case of potential problems.

Building on the inspection model described in [1], we model our problem as a two person zero sum game between a firm and an employee. Each player has two possible actions: *legal* and *fraud* for the employee, and *audit* and *no-audit* for the firm. All payoffs are measured in the same units (*i.e.* amount of hryvnias, UAH). We assume that an internal audit discovers any attempt at fraud. The game may be specified using the following parameters:

- L: Firm's loss resulting from fraud.
- c: Firm's cost for conducting an audit.
- γ: Employee's gain resulting from fraud.
- κ: Employee incurs a penalty of $\kappa\gamma$ when fraud is discovered ($\kappa > 1$).
- θ: Fraction of the firm's loss recovered when fraud is detected through audit.

The table below presents the loss for firm and the gain for the employee under the four possible combinations of action pairs.

The employee decides on the probability of committing fraud while the firm decides on the probability of conducting an audit. Let the strategic decision variables for the players be:

- π: Probability of conducting an audit (firm decides on this).

Table 1.

Matrix of firm's and employee's payoffs without expert system

	Employee's strategy	
Firm's strategy	Fraud	Legal
Audit	$(c+(1-\theta)L,-(\kappa-1)\gamma$	$(c,0)$
No Audit	(L,γ)	$(0,0)$

- ϱ: Probability of fraud by employee (employee decides on this).
- We derive the following conditions for **Nash equilibrium** under a mixed strategy game:
- $\pi = 1/\kappa$;

- $\varrho = c/(\theta L)$

We obtain π by ensuring that the employee's expected payoff for committing fraud equals its expected payoff for not committing fraud. To obtain ϱ we ensure the firm's expected payoff when it conducts audit equals its expected payoff when the firm does not conduct audit.

Implication on firm's policy: We assume that the employee's gain from fraud (γ) is exogenous (i.e. beyond the firm's control). To reduce expected costs, the firm should set the penalty factor κ to be sufficiently high so that an employee has very little incentive to attempt fraud. Further, the firm should improve the auditing process so as to increase the fraction (θ) of loss recovered from discovery of fraud.

Decision to deploy an expert system for auditing:

Next we consider a case where the firm may deploy an expert system for auditing that raises alarms when a potential fraud is detected. The performance of the expert system may be modeled using the following parameters:

- P_D: Probability that expert system detects a fraud.
- P_F: Probability that expert system raises a false alarm.

The employee decides on the probability of committing fraud while the firm decides on the probability of conducting an audit under two different scenarios: (i) when the expert system generates an alarm, and (ii) when no alarm is generated. Let the strategic decision variables for the players be:

- ϱ: Probability of fraud by employee (employee decides on this).
- π_a: Probability of audit when expert system generates an alarm.
- π_n: Probability of audit when expert system generates no alarm.

The loss for firm and the gain for the employee under all possible combinations of action pairs is summarized in the table below.

Table 2

Matrix of firm's and employee's strategies with and without expert system

Firm's strategy		**Employee's strategy**	
Alarm	No Alarm	Fraud	Legal
Audit	Audit	$(c+(1-\theta)L, -(\kappa-1)\gamma)$	$(c,0)$
Audit	No Audit	$((c+(1-\theta)L)P_D + L(1-P_D), \gamma(1-\kappa P_D))$	$(cP_F,0)$
No Audit	Audit	$((c+(1-\theta)L)(1-P_D)+LP_D, \gamma(1-(1-P_D)\kappa)$	$(c(1-P_F),0)$
No Audit	No Audit	(L,μ)	$(0,0)$

Using the same approach as above, we can obtain the mixed strategies for the players under Nash equilibrium as follows:

Case 1. If $P_D < 1/\kappa$ (That is, the detection rate is too low)

- $Q = \frac{c(1-P_F)}{c(P_D-P_F)+(1-P_D)\theta L}$; $\pi_a = 1$; $\pi_n = \frac{1-\kappa P_D}{\kappa(1-P_D)}$
- Case 2. If $P_D \geq 1/\kappa$ (That is, the detection rate is sufficiently high)
- $Q = \frac{cP_F}{P_D\theta L - c(P_D - P_F)}$; $\pi_a = \frac{1}{\kappa P_D}$; $\pi_n = 0$

Policy implications for the firm:

- The firm should NOT use an expert system unless it can guarantee that the detection rate of the expert system is sufficiently high ($P_D \geq 1/\kappa$). Otherwise, expected cost for the firm can be higher when it uses an expert system than when it does not.

- The expected decrease in cost for the firm when using an expert system with $P_D \geq 1/\kappa$ over not using an expert system is given by: $\frac{(P_D-P_F)(L\theta-c)}{L\theta P_D - c(P_D-P_F)}\frac{c}{\theta}$. This gives a bound for the maximum amount that the firm should be willing to pay for an expert system with the given performance and may be interpreted as the value of the expert system to the firm.

- Probability of false positive for any expert system increases with the probability of detection; the two are related by the receiver operating characteristics (ROC) with $P_D = P_F^r$ for $0 < r < 1$.; the lower the r, the better the performance. For a given r, the expected value of the expert system to the firm may be maximized by setting $P_D = 1/\kappa$, and hence $P_F = (1/\kappa)^{1/r}$.

- Under these optimal setting, we have $\pi_a = 1$; $\pi_n = 0$. That is, the firm should perform an audit if and only if the expert system raises an alarm. That is, under this optimal setting the firm can treat the expert system as though it as a crystal ball with perfect predictive accuracy.

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