Simulation of the Role of Emphasis on Scheduling in the Optimal Incentive Scheme for Employee's Routine Job and Information Security Compliance

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Abstract: In the organizational context, employee individual often prefers to concentrate herself to the day-to-day routine job, but to shirk the responsibilities of the Information Security Policies (ISPs) compliance, after she has been delegated by the employer to perform the two different tasks in the same time period. This would lead to negative influences on the security of information systems and the employee's routine job performance. In view of the task structures of employee's routine job and ISPs compliance, the variables of emphasis on scheduling are incorporated into a multi-task principal-agent model to explore the optimal incentive scheme to motivate and control the employees to select appropriate effort levels for conducting the two highly structured tasks. The role of emphasis on scheduling on the incentive intensities for the two tasks have been clarified through the system modeling and simulation, and the corresponding incentive tactics are suggested. The two-task incentive scheme is expected to provide useful insight for understanding and controlling employee's routine job and ISPs compliance behaviors.

1. Introduction

Information Security Policies (ISPs) have been established in many organizations to safeguard their information systems [1-4]. When interacting with these systems, the employees are required to comply with the specific rules and responsibilities formulated by the ISPs [5-8]. The ISPs are only effective to the extent that employees comply with them [7]. In practice, many employees often prefer to comply with the ISPs with insufficient effort, but to pay attention almost exclusively to their day-to-day routine jobs, after they are delegated by the employer to carry out the two different tasks in the same time period [9-10]. Previous investigations [11-19] have shown that employee's failure to comply with the ISPs may impair not only the asset, reputation and competitiveness of the organization, but also the performance of her routine job [9, 10, 20]. A number of factors, such as information security awareness, organizational culture and punishment, are known to influence employee's intentional compliance behaviors [7, 14, 16, 17, 21]. However, the selection of the ISPs compliance effort levels is rarely discussed in a multi-task context in the previous studies. In most cases, the ISPs compliance task is bound with the employee's routine job because the completing of her routine job needs to use the information systems. Task dissonance, i.e., the discord arising in employee's cognition of conflicting utilities between her routine job and ISPs compliance, may appear [22]. For instance, sending an encrypted e-mail according to the specific security rules requires more steps than sending a regular e-mail. The additional complication of sending the encrypted e-mail is considered by the employee as extra work load without any payoffs. The employee would perceive that the ISPs compliance task interferes with her routine job [20, 23]. Although the employer expects that the routine job and the ISPs compliance task are both performed by the employee with high efforts, the latter is often ignored. Therefore, motivating an employee to allocate appropriately her efforts between the two tasks appears to be crucial for eliminating the security threats from the ISPs non-compliance and improving her routine job

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performance.

There exist a few recent studies dealing with the allocation of employee's efforts for the information security compliance from the economic perspective. Beautement et al. [9, 10] proposed a concrete paradigm, i.e., the compliance budget, to understand the expense of employee's effort for the compliance task. Their results indicate that the employee's compliance budget can be used by the employer to grasp how an employee perceives the cost and benefit of her compliance. Herath and Rao [23] pointed out that a moral hazard problem naturally occurs because the information security compliance behavior of an employee is hard to be monitored constantly by the employer without high costs. Fang et al. [24] further proposed a comprehensive mechanism that can address the moral hazard problem, provide accountability and offer incentives at the inter-organizational level under some specified conditions. Apart from the moral hazard problem, cost substitution [25] may also exist between the routine job and the ISPs compliance task. In such a case, an employee is likely to select performing her routine job with high effort but shirking the compliance duty. Therefore, an incentive scheme is necessarily needed to motivate the employee to allocate appropriate efforts for the two different tasks.

For the design of an optimal incentive scheme, the specificity of the ISPs compliance task should be considered. From the task structure [26, 27] point of view, the ISPs compliance task is highly structured since the task-related duties and responsibilities are clearly defined in the ISPs. It has been demonstrated that the psychological state that an employee experiences while performing a highly structured task may negatively influence the organizationally valued outcomes, such as job involvement and organizational commitment [26-35]. Hence, a high task structure of the ISPs compliance may decrease the quality of the compliance performance of an employee. Considering that the absence of ambiguity in a highly structured task matches the employee's strong preference to know how to schedule her activities involved in the task, emphasis on scheduling has been found to be capable of moderating the negative effects of task structure [27, 36-39]. Here, emphasis on scheduling refers to how the employee structures and makes sense of her social world in a temporal sense, which is a selective facet of the temporal orientation at the individual level [27, 29, 40]. For an employee who places high emphasis on scheduling, the negative effects of a highly structured task are weaker than for the one who does not emphasize scheduling of activities [27]. Since the principal-agent theory inherently lacks the recognition of the temporal preferences of human behaviors [23, 41, 42], emphasis on scheduling may be incorporated as a variable into the principal-agent theory to design the incentive scheme. In the present study, the variables of emphasis on scheduling are combined with the multi-task principal-agent model to explore a two-task optimal incentive scheme for motivating employee individual to allocate appropriate efforts for her routine job and ISPs compliance task.

The remainder of this study is organized as follows. In Section II, a contract model is proposed for the design of the optimal incentive scheme, from which an optimization problem is derived. In Section III, the optimization problem is solved, and numerical examples are used to show the stand-alone and the correlated influences of the two variables of emphasis on scheduling on the incentive intensity. The incentive tactics applicable for the two tasks are obtained. Concluding remarks of this study are given in Section IV.

2. An optimal incentive contract

A series of assumptions are made to keep our analysis tractable.

(1) Assume that employer and employee are independent individuals in an organization. Consider a two-task principal-agent problem in which an employer (the principal) delegates an employee (the agent) to perform the routine job and the information security compliance in the same period of time.

(2) Assume that the routine job is also a highly structured task because it consists of fairly standard and repetitive duties that fill the entire work cycle in a given period of time.

(3) Suppose a two-dimensional (2D) vector for the employee's effort levels, which is a one-time

selection [25, 43], $e = \begin{pmatrix} e_1 \\ e_2 \end{pmatrix}$, where e_1 and e_2 represent the effort levels selected by an employee for her routine job and ISPs compliance task, respectively. The employee knows her effort levels for the two different tasks, but the effort levels cannot be measured at low cost by the employer.

(4)Suppose an observable 2D outcome vector, $o = \begin{pmatrix} o_1 \\ o_2 \end{pmatrix}$, for the two tasks. Since an employee who emphasizes the scheduling of the various activities involved in her task fits better with a highly structured task, and is likely to be more productive, we let the outcome of the routine job $o_1 = p_1 e_1 + \theta_1$, and that of the ISPs compliance task $o_2 = p_2 e_2 + \theta_2$. Here, p_1 and p_2 are the two variables of emphasis on scheduling, which correspond to the routine job and the ISPs compliance task, respectively, $0 \le p_1 \le 1$, $0 \le p_2 \le 1$. Each of the variables affects merely the outcome of the effort for the task it corresponds. θ_1 and θ_2 are unobservable exogenous variables, which are related to the routine job and the ISPs compliance task, respectively, and are independent variables. For example, θ_1 and θ_2 can be used to represent the errors of the performance evaluations of an employee's routine job and ISPs compliance task, respectively. θ_1 follows a normal distribution with a zero mean value and a variance of σ_1^2;θ_2 is also normally distributed with mean value zero, but with variance σ_2^2. The larger value of θ_1 (or θ_2) signals a more favorable state of the exogenous condition. Let $\theta = \begin{pmatrix} \theta_1 \\ \theta_2 \end{pmatrix}$, where θ is a random vector normally distributed with mean vector zero and covariance matrix Σ, $\Sigma = \begin{pmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{pmatrix}$. Assume that the distributions of o_1 and o_2 satisfy the first-order stochastic dominance condition. Hence, a larger value of o_1 (or o_2) implies that a higher effort level for the routine job (or the ISPs compliance task) has been selected by the employee.

(5) Assume that the employer is risk neutral, whereas the employee is risk averse.

(6) Assume that the personal cost of the employee's efforts can be expressed by a strictly convex function, $C(e) = \frac{1}{2} C_{11} e_1^2 + C_{12} e_1 e_2 + \frac{1}{2} C_{22} e_2^2$. Here, $C(e)$ is expressed in monetary units. We obtain: $C_{11} = \frac{\partial^2 C(e)}{\partial e_1^2}$, $C_{12} = \frac{\partial^2 C(e)}{\partial e_1 e_2}$, and $C_{22} = \frac{\partial^2 C(e)}{\partial e_2^2}$.

(7) Assume that both the employer and the employee prefer to maximize their own expected utilities, and that the employer will stick to her promise and is able to offer monetary compensation to the employee.

(8) The distributions of o_1, o_2,θ_1,θ_2, and the von Neumann-Morgenstern utility functions, etc., are common knowledge shared by the employer and the employee.

Based on the above assumptions, the gross benefit, $B(e)$, takes the form

$$B(e) = o_1 + o_2 = p_1 e_1 + p_2 e_2 + \theta_1 + \theta_2 \tag{1}$$

where the ownership of $B(e)$ belongs to the employer. The employer can offer an incentive contract, $s(o)$, to induce the employee to carry out both the routine job and the ISPs compliance with the effort levels expected by the employer:

$$s(o) = \beta_1 + \gamma^T o = \beta_1 + \gamma_1 o_1 + \gamma_2 o_2 \beta_1 + \gamma_1 (p_1 e_1 + \theta_1) + \gamma_2 (p_2 e_2 + \theta_2) \tag{2}$$

where β_1 is a fixed income of the employee. β_1 is not relevant to the outcome, o, which is determined by the reservation utility of the employee, $\bar{u}_1$, i.e., the expected utility she can achieve by working elsewhere. γ_1 and γ_2 are the share ratios of the employee, viz., two incentive coefficients, and relation (2) means that the incentive intensity increases by γ_1(or γ_2) with one unit increment in o_1 (or o_2). Let $\gamma = \begin{pmatrix} \gamma_1 \\ \gamma_2 \end{pmatrix}$ and $\gamma^T = (\gamma_1 \ \gamma_2)$, where the superscript T stands for a transpose operator.

Then, the net benefit of the employer is given by

$$B(e) - s(o) = (p_1 e_1 + p_2 e_2 + \theta_1 + \theta_2) - \big(\beta_1 + \gamma_1 (p_1 e_1 + \theta_1) + \gamma_2 (p_2 e_2 + \theta_2)\big) \tag{3}$$

Hence, the expected payoff of the employer is

$$E\big(B(e)-s(o)\big)=(1-\gamma_1)p_1e_1+(1-\gamma_2)p_2e_2-\beta_1 \tag{4}$$

And meanwhile, the certainty equivalence monetary payoff of the employee is

$$\begin{aligned}&E\big(s(o)-C(e)\big)-\left(\frac{1}{2}\eta_1\gamma^T\Sigma\gamma\right)\\&=(\beta_1+\gamma_1p_1e_1+\gamma_2p_2e_2)-\left(\frac{1}{2}C_{11}e_1^2+C_{12}e_1e_2+\frac{1}{2}C_{22}e_2^2\right)\\&-\left(\frac{1}{2}\eta_1\gamma_1^2\sigma_1^2+\frac{1}{2}\eta_1\gamma_2^2\sigma_2^2\right)\end{aligned} \tag{5}$$

where $E\big(s(o)-C(e)\big)$ is the mathematical expectation of $s(o)-C(e)$, $\frac{1}{2}\eta_1\gamma^T\Sigma\gamma$gives the risk premium of the employee, η_1 measures the employee's risk aversion, and since the employee is risk averse, $\eta_1>0$, $\gamma^T\Sigma\gamma$ is the variance of the employee's payoff once she accepts the contract and makes efforts to perform her routine job and information security policies compliance.

If the magnitude of the certainty equivalence is smaller than that of the employee's reservation utility,$\bar{u}_1$, the employee will decline the contract. Then, the individual rationality constraint of the employee can be expressed by the following relation:

$$(\beta_1+\gamma_1p_1e_1+\gamma_2p_2e_2)-\left(\frac{1}{2}C_{11}e_1^2+C_{12}e_1e_2+\frac{1}{2}C_{22}e_2^2\right)-\left(\frac{1}{2}\eta_1\gamma_1^2\sigma_1^2+\frac{1}{2}\eta_1\gamma_2^2\sigma_2^2\right)\geq\bar{u}_1 \tag{6}$$

The incentive compatibility constraint of the employee is

$$\begin{aligned}(e_1,e_2)\in Argmax\Bigg(&(\beta_1+\gamma_1p_1e_1+\gamma_2p_2e_2)-\left(\frac{1}{2}C_{11}e_1^2+C_{12}e_1e_2+\frac{1}{2}C_{22}e_2^2\right)\\&-\left(\frac{1}{2}\eta_1\gamma_1^2\sigma_1^2+\frac{1}{2}\eta_1\gamma_2^2\sigma_2^2\right)\Bigg)\end{aligned} \tag{7}$$

Suppose that the employer wishes to obtain the optimal expected payoff. The following problem can be solved by means of picking β_1, γ_1 and γ_2:

$$\underset{\beta_1,\gamma_1,\gamma_2}{Max}\big((1-\gamma_1)p_1e_1+(1-\gamma_2)p_2e_2-\beta_1\big)$$

s.t.

$$\begin{aligned}&\left((\beta_1+\gamma_1p_1e_1+\gamma_2p_2e_2)-(\tfrac{1}{2}C_{11}e_1^2+C_{12}e_1e_2+\tfrac{1}{2}C_{22}e_2^2)\right)-\left(\tfrac{1}{2}\eta_1\gamma_1^2\sigma_1^2+\tfrac{1}{2}\eta_1\gamma_2^2\sigma_2^2\right)\geq\bar{u}_1,\\&(e_1,e_2)\in Argmax\left((\beta_1+\gamma_1p_1e_1+\gamma_2p_2e_2)-(\frac{1}{2}C_{11}e_1^2+C_{12}e_1e_2+\frac{1}{2}C_{22}e_2^2)\right)\\&\qquad-\left(\frac{1}{2}\eta_1\gamma_1^2\sigma_1^2+\frac{1}{2}\eta_1\gamma_2^2\sigma_2^2\right)\end{aligned} \tag{8}$$

3. Analysis of the optimal incentive scheme

In the following, the two variables of emphasis on scheduling (p_1, p_2) are first demonstrated to have stand-alone or correlated influences on the incentive intensities (γ_1, γ_2) applied to the routine job or the information security compliance, and then the corresponding incentive tactics are suggested.

First, for the employer, the optimal incentive contract should satisfy the equality relation in (6). So,

$$\beta_1 = \bar{u}_1 - (\gamma_1 p_1 e_1 + \gamma_2 p_2 e_2) + \left(\frac{1}{2}C_{11}e_1^2 + C_{12}e_1 e_2 + \frac{1}{2}C_{22}e_2^2\right) + \left(\frac{1}{2}\eta_1\gamma_1^2\sigma_1^2 + \frac{1}{2}\eta_1\gamma_2^2\sigma_2^2\right) \tag{9}$$

Insert (9) into (4), and express the employer's expected payoff into the matrix form:

$$E\big(B(e) - s(o)\big) =$$
$$(p_1 p_2)\begin{pmatrix} e_1 \\ e_2 \end{pmatrix} - \bar{u}_1 - \frac{1}{2}(e_1 e_2)\begin{pmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{pmatrix}\begin{pmatrix} e_1 \\ e_2 \end{pmatrix} - \frac{1}{2}\eta_1(\gamma_1\gamma_2)\begin{pmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{pmatrix}\begin{pmatrix} \gamma_1 \\ \gamma_2 \end{pmatrix} \tag{10}$$

Assume that $\begin{pmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{pmatrix}$ is reversible. From (7), we obtain

$$\begin{pmatrix} e_1 \\ e_2 \end{pmatrix} = \begin{pmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{pmatrix}^{-1}\begin{pmatrix} \gamma_1 p_1 \\ \gamma_2 p_2 \end{pmatrix} \tag{11}$$

Therewith, the expected pay off of the employer is worked out by inserting (11) into (10),

$$E\big(B(e) - s(o)\big) =$$
$$(p_1 p_2)\begin{pmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{pmatrix}^{-1}\begin{pmatrix} \gamma_1 p_1 \\ \gamma_2 p_2 \end{pmatrix} - \bar{u}_1 - \frac{1}{2}(\gamma_1 p_1\ \gamma_2 p_2)\begin{pmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{pmatrix}^{-1}\begin{pmatrix} \gamma_1 p_1 \\ \gamma_2 p_2 \end{pmatrix} - \frac{1}{2}\eta_1(\gamma_1\gamma_2)\begin{pmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{pmatrix}\begin{pmatrix} \gamma_1 \\ \gamma_2 \end{pmatrix} \tag{12}$$

The objective function

$$\underset{\beta,\gamma_1,\gamma_2}{Max}\big((1-\gamma_1)p_1 e_1 + (1-\gamma_2)p_2 e_2 - \beta_1\big)$$

can be expressed as

$$\underset{\gamma_1,\gamma_2}{Max}\left((p_1 p_2)\begin{pmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{pmatrix}^{-1}\begin{pmatrix} \gamma_1 p_1 \\ \gamma_2 p_2 \end{pmatrix} - \bar{u}_1 - \frac{1}{2}(\gamma_1 p_1\ \gamma_2 p_2)\begin{pmatrix} C_{11} & C_{12} \\ C_{12} & C_{22} \end{pmatrix}^{-1}\begin{pmatrix} \gamma_1 p_1 \\ \gamma_2 p_2 \end{pmatrix} - \frac{1}{2}\eta(\gamma_1\gamma_2)\begin{pmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{pmatrix}\begin{pmatrix} \gamma_1 \\ \gamma_2 \end{pmatrix}\right) \tag{13}$$

Finally, the two incentive coefficients corresponding to the routine job and the information security compliance are derived:

$$\gamma_1 = \Big((C_{22}p_1^2 - C_{12}p_1p_2)(C_{11}p_2^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_2^2) + (C_{12}p_1p_2)(C_{11}p_2^2 - C_{12}p_1p_2)\Big) \Big/ \Big((C_{22}p_1^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_1^2)(C_{11}p_2^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_2^2) - (C_{12}p_1p_2)^2\Big) \tag{14}$$

$$\gamma_2 = \Big((C_{11}p_2^2 - C_{12}p_1p_2)(C_{22}p_1^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_1^2) + (C_{12}p_1p_2)(C_{22}p_1^2 - C_{12}p_1p_2)\Big) \Big/ \Big((C_{22}p_1^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_1^2)(C_{11}p_2^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_2^2) - (C_{12}p_1p_2)^2\Big) \tag{15}$$

It is seen from (14) and (15) that the two variables of emphasis on scheduling, p_1 and p_2, have stand-alone or correlated influences on the incentive intensities applied to the routine job or the ISPs compliance. In the following, the specific stand-alone or correlated influences are first clarified, and based on which the incentive tactics for the two tasks are suggested. Besides this, several numerical examples are presented to examine the role of emphasis on scheduling in the incentive scheme. All these results are summarized in Tables 1, 2, and 3.

(1) When the effort cost of the employee's routine job is independent of that of the ISPs compliance, viz., $C_{12} = 0$, the incentive coefficient and the corresponding incentive tactics are determined in four different cases based on the observability of the task outcomes:

(*i*) When the outcomes of the routine job and the compliance task are not observable, viz., $\sigma_1^2 \to \infty$ and $\sigma_2^2 \to \infty$,$\gamma_1 = 0$and$\gamma_2 = 0$. Based on this result, the incentive component should not be offered to the two tasks. Here, p_1 and p_2 are not relevant to γ_1 and γ_2.

Table 1. Three numerical examples for $C_{12} = 0$

Numerical examples	**Value assignment**	**Incentive coefficients**
*NE*1	$C_{11} = 0$, $\eta_1 = 0.5$, $\sigma_1^2 = 1$, and $0 \leq p_1 \leq 1$.	$\gamma_1 = \frac{1}{1+0.25/p_1^2}$, $\gamma_2 = 0$.
*NE*2	$C_{22} = 0.8$, $\eta_1 = 0.5$, $\sigma_2^2 = 10$, and $0 \leq p_2 \leq 1$.	$\gamma_1 = 0$, $\gamma_2 = \frac{1}{1+4/p_2^2}$.
*NE*3	$C_{11} = 0.5$, $C_{22} = 0.9$, $\eta_1 = 0.5$, $\sigma_1^2 = 1$, $\sigma_2^2 = 10$, $0 \leq p_1 \leq 1$, and $0 \leq p_2 \leq 1$.	$\gamma_1 = \frac{p_1^2}{p_1^2+0.25}$, $\gamma_2 = \frac{p_2^2}{p_2^2+4.5}$.

Table 2. Three numerical examples for $C_{12} < 0$

Numerical examples	**Value assignment**	**Intensive coefficients**
*NE*4	$C_{11} = 0.5$, $C_{12} = -0.7$, $C_{22} = 0.5$, $\eta_1 = 0.5$, $\sigma_1^2 = 1$, $0 \leq p_1 \leq 1$, and $0 \leq p_2 \leq 1$.	$\gamma_1 = \frac{0.5p_1^2+0.7p_1p_2}{0.5p_1^2-0.12}$, $\gamma_2 = 0$.
*NE*5	$C_{11} = 0.5$, $C_{12} = -0.7$, $C_{22} = 0.5$, $\eta_1 = 0.5$, $\sigma_2^2 = 0.5$, $0 \leq p_1 \leq 1$, and $0 \leq p_2 \leq 1$.	$\gamma_1 = 0$, $\gamma_2 = \frac{0.5p_2^2+0.7p_1p_2}{0.5p_2^2-0.06}$.
*NE*6	$C_{11} = 0.5$, $C_{12} = -0.7$, $C_{22} = 0.5$, $\eta_1 = 0.5$, $\sigma_1^2 = 1$, $\sigma_2^2 = 0.5$, $0 \leq p_1 \leq 1$, and $0 \leq p_2 \leq 1$.	$\gamma_1 = \frac{\left((0.5p_1^2+0.7p_1p_2)(0.5p_2^2-0.06)- (0.7p_1p_2)(0.5p_2^2+0.7p_1p_2)\right)}{\left((0.5p_1^2-0.12)(0.5p_2^2-0.06)- (0.7p_1p_2)^2\right)}$, $\gamma_2 = \frac{\left((0.5p_2^2+0.7p_1p_2)(0.5p_1^2-0.12)- (0.7p_1p_2)(0.5p_1^2+0.7p_1p_2)\right)}{\left((0.5p_1^2-0.12)(0.5p_2^2-0.06)- (0.7p_1p_2)^2\right)}$.

Table 3. Three numerical examples for $C_{12} > 0$

Numerical examples	**Values assignment**	**Intensive coefficients**
NE7	$C_{11} = 0.5$, $C_{12} = 1$, $C_{22} = 0.5$, $\eta_1 = 0.5$, $\sigma_1^2 = 1$, $0 \le p_1 \le 1$, and $0 \le p_2 \le 1$.	$\gamma_1 = \frac{0.5p_1^2 - p_1p_2}{0.5p_1^2 - 0.375}$, $\gamma_2 = 0$.
	high degree substitution, $C_{11} = 0.5$, $C_{12} = 10$, $C_{22} = 0.5$, $\eta_1 = 0.5$, $\sigma_1^2 = 1$, $0 \le p_1 \le 1$, and $0 \le p_2 \le 1$.	$\gamma_1 = \frac{0.5p_1^2 - 10p_1p_2}{0.5p_1^2 - 49.875}$, $\gamma_2 = 0$.
NE8	$C_{11} = 0.5$, $C_{12} = 1$, $C_{22} = 0.5$, $\eta_1 = 0.5$, $\sigma_2^2 = 0.5$, $0 \le p_2 \le 1$, and $0 \le p_2 \le 1$.	$\gamma_1 = 0$, $\gamma_2 = \frac{0.5p_2^2 - p_1p_2}{0.5p_2^2 - 0.1875}$.
	high degree substitution, $C_{11} = 0.5$, $C_{12} = 10$, $C_{22} = 0.5$, $\eta_1 = 0.5$, $\sigma_2^2 = 0.5$, $0 \le p_2 \le 1$, and $0 \le p_2 \le 1$.	$\gamma_1 = 0$, $\gamma_2 = \frac{0.5p_2^2 - 10p_1p_2}{0.5p_2^2 - 24.9375}$.
*NE*9	$C_{11} = 0.5$, $C_{12} = 0.7$, $C_{22} = 0.5$, $\eta_1 = 0.5$, $\sigma_1^2 = 1$, $\sigma_2^2 = 0.5$, $0 \le p_2 \le 1$, and $0 \le p_2 \le 1$.	$\gamma_1 = \frac{\left((0.5p_1^2 - 0.7p_1p_2)(0.5p_2^2 - 0.06) + (0.7p_1p_2)(0.5p_2^2 - 0.7p_1p_2)\right)}{\left((0.5p_1^2 - 0.12)(0.5p_2^2 - 0.06) - (0.7p_1p_2)^2\right)}$, $\gamma_2 = \frac{\left((0.5p_2^2 - 0.7p_1p_2)(0.5p_1^2 - 0.12) + (0.7p_1p_2)(0.5p_1^2 - 0.7p_1p_2)\right)}{\left((0.5p_1^2 - 0.12)(0.5p_2^2 - 0.06) - (0.7p_1p_2)^2\right)}$.

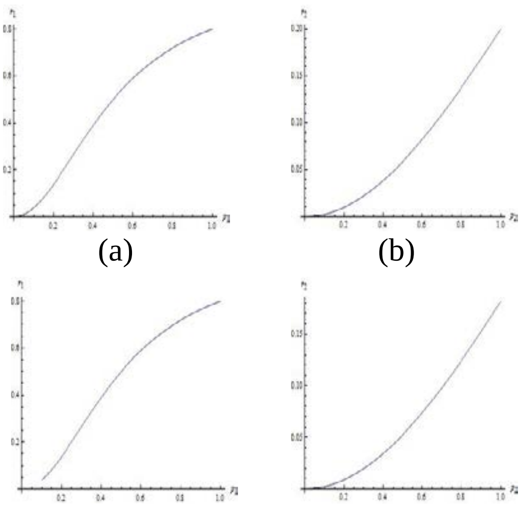

Figure 1. γ_1,γ_2 as a function of p_1 or p_2 (when $C_{12} = 0$) for (a) *NE*1, (b) *NE*2, and (c) and (d) *NE*3, (*NE*: numerical example).

(*ii*) When the outcome of the routine job is observable and that of the compliance task is not, viz., σ_1^2 is finite and $\sigma_2^2 \to \infty$, $\gamma_1 = \frac{1}{1+C_{11}\eta_1\sigma_1^2/p_1^2}$ and $\gamma_2 = 0$. In this case, the routine job should be rewarded in accord with γ_1, and the compliance task should not be rewarded. p_1 exerts a stand-alone influence on γ_1, whereas p_2 has no effect on γ_2. A numerical example, *NE*1, is used to show the influence of p_1 on γ_1, and the explicit relationship of p_1 with γ_1 is illustrated in Fig. 1(a). γ_1 is seen to increase monotonically with increasing p_1.

(*iii*) When the outcome of the compliance task is observable, but that of the routine job is not, viz., $\sigma_1^2 \to \infty$ and σ_2^2 is finite, $\gamma_1 = 0$ and $\gamma_2 = \frac{1}{1+C_{22}\eta_1\sigma_2^2/p_2^2}$. Therewith, the compliance task should be rewarded in accord with γ_2. Moreover, p_2 exerts a stand-alone influence on γ_2, whereas p_1 does not influence γ_1. The influence of p_2 on γ_2 is demonstrated by a numerical example, *NE*2, and the increasing tendency of γ_2 versus p_2 is shown in Fig. 1(b).

(*iv*) When the outcomes of the two tasks are both observable, viz., σ_1^2 and σ_2^2 take finite values, $\gamma_1 = \frac{p_1^2}{p_1^2+C_{11}\eta_1\sigma_1^2}$ and $\gamma_2 = \frac{p_2^2}{p_2^2+C_{22}\eta_1\sigma_2^2}$. In this case, both of the two tasks should be rewarded. p_1 and p_2 exert a stand-alone influence on γ_1 and γ_2, respectively. A numerical example, *NE*3, along with Figs. 1(c) and 1(d) are used to show the increasing tendencies of γ_1 and γ_2 versus p_1 and p_2.

(2) When a complementary relationship exists between the effort cost of employee's routine job and that of her ISPs compliance task, viz., $C_{12} < 0$, the incentive coefficients and tactics are obtained under four different conditions.

(*i*) When the outcomes of the routine job and the compliance task are not observable, viz., $\sigma_1^2 \to \infty$ and $\sigma_2^2 \to \infty$, $\gamma_1 = 0$ and $\gamma_2 = 0$. This means p_1 and p_2 are not relevant to γ_1 and γ_2. In this case, the incentive component should not be offered to either of the two tasks.

(*ii*) When the outcome of the routine job is observable, and that of the compliance task is not, viz., σ_1^2 is finite and $\sigma_2^2 \to \infty$, $\gamma_1 = \frac{C_{22}p_1^2 - C_{12}p_1p_2}{C_{22}p_1^2+(C_{11}C_{22}-C_{12}^2)\eta_1\sigma_1^2}$ and $\gamma_2 = 0$. Therefore, the routine job should be rewarded in accord with γ_1, and the compliance task should not be rewarded. Because $C_{12} < 0$, γ_1 increases with decreasing C_{12}. p_1 and p_2 exert a correlated influence on γ_1, but do not influence γ_2. This kind of correlated influence is demonstrated by a numerical example, *NE*4, and is illustrated in Fig. 2 (a).

(*iii*) When the outcome of the compliance task is observable, and that of the routine job is not, viz., $\sigma_1^2 \to \infty$ and σ_2^2 is finite, $\gamma_1 = 0$ and $\gamma_2 = \frac{C_{11}p_2^2 - C_{12}p_1p_2}{C_{11}p_2^2+(C_{11}C_{22}-C_{12}^2)\eta_1\sigma_2^2}$. Therewith, the reward component paid to the compliance task should be increased in accord with γ_2, but should not be offered to the routine job. Notice $C_{12} < 0$. γ_2 is an increasing function of C_{12}. p_1 and p_2 exert a correlated influence on γ_2, but have no influence on γ_1. Fig. 2 (b) shows the specific correlated influence given by a numerical example, *NE*5.

(*iv*) When the outcomes of the two tasks are both observable, viz., σ_1^2 and σ_2^2 take finite values, the incentive coefficients turn to be

$$\gamma_1 = \frac{(C_{22}p_1^2-C_{12}p_1p_2)(C_{11}p_2^2+(C_{11}C_{22}-C_{12}^2)\eta_1\sigma_2^2)+(C_{12}p_1p_2)(C_{11}p_2^2-C_{12}p_1p_2)}{(C_{22}p_1^2+(C_{11}C_{22}-C_{12}^2)\eta_1\sigma_1^2)(C_{11}p_2^2+(C_{11}C_{22}-C_{12}^2)\eta_1\sigma_2^2)-(C_{12}p_1p_2)^2},$$

$$\gamma_2 = \frac{(C_{11}p_2^2-C_{12}p_1p_2)(C_{22}p_1^2+(C_{11}C_{22}-C_{12}^2)\eta_1\sigma_1^2)+(C_{12}p_1p_2)(C_{22}p_1^2-C_{12}p_1p_2)}{(C_{22}p_1^2+(C_{11}C_{22}-C_{12}^2)\eta_1\sigma_1^2)(C_{11}p_2^2+(C_{11}C_{22}-C_{12}^2)\eta\sigma_2^2)-(C_{12}p_1p_2)^2}.$$

In this case, the routine job and the ISPs compliance task should be rewarded in accord with γ_1 and γ_2, respectively. p_1 and p_2 exert a correlated influence on the incentive intensities applied to the two tasks. A numerical example, *NE*6, is presented to show this correlated influence, and the result is illustrated in Figs. 2 (c) and (d).

(3) When substitution exists between the employee's effort cost of the routine job and that of the ISPs compliance, viz., $C_{12} > 0$, the specific incentive coefficients and tactics can also be obtained under four different conditions:

(*i*) When the outcomes of the routine job and the compliance task are not observable, viz.,

$\sigma_1^2 \to \infty$ and $\sigma_2^2 \to \infty$, $\gamma_1 = 0$ and $\gamma_2 = 0$. Hence, the reward should not be offered to the two tasks. Here, p_1 and p_2 are not relevant to γ_1 and γ_2.

(*ii*) When the outcome of the routine job is observable, and that of the compliance task is not, viz.,$\sigma_1^2$is finiteand$\sigma_2^2 \to \infty$,$\gamma_1 = \frac{C_{22}p_1^2 - C_{12}p_1p_2}{C_{22}p_1^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_1^2}and\gamma_2 = 0$. Because of cost substitution,γ_1 should be decreased to prevent the employee from only focusing on her routine job. The higher the degree of substitution is, the lower should be the incentive intensity applied to the routine job. p_1 and p_2 exert a correlated influence on γ_1, but do not influence γ_2. This correlated influence is shown by a numerical example, *NE*7, and is illustrated in Figs. 3 (a) and (b).

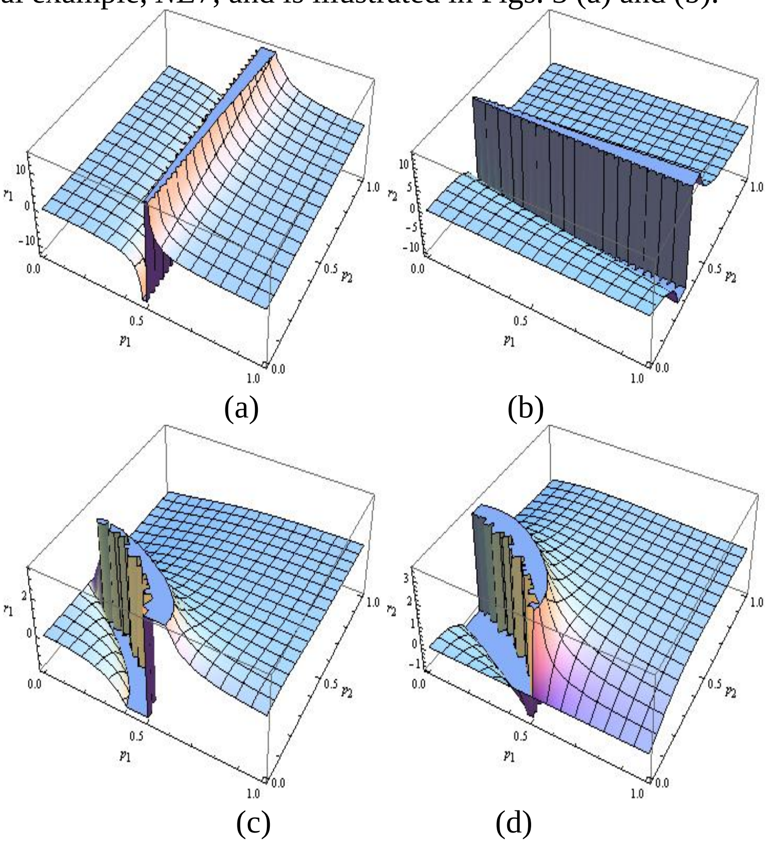

Figure 2. γ_1,γ_2 as a function of both p_1 and p_2 (when $C_{12} < 0$) for (a) *NE*4, (b) *NE*5, and (c) and (d) *NE*6, (*NE*: numerical example).

(*iii)* When the outcome of the compliance task is observable, but that of the routine job is not, viz., $\sigma_1^2 \to \infty$ and σ_2^2 is finite, $\gamma_1 = 0$ and $\gamma_2 = \frac{C_{11}p_2^2 - C_{12}p_1p_2}{C_{11}p_2^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_2^2}$. Therewith, the routine job should not be rewarded. Although the compliance task should be rewarded according to γ_2, the incentive intensity should be reduced to prevent the employee from only focusing on her compliance task, and as the degree of substitution increases, the incentive intensity should be further reduced. This correlated influence is shown by a numerical example, *NE*8, along with Figs. 3 (c) and (d).

(*iv*) When the outcomes of the two tasks are both observable, viz., σ_1^2 and σ_2^2 are finite,

$$\gamma_1 = \frac{(C_{22}p_1^2 - C_{12}p_1p_2)(C_{11}p_2^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_2^2) + (C_{12}p_1p_2)(C_{11}p_2^2 - C_{12}p_1p_2)}{(C_{22}p_1^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_1^2)(C_{11}p_2^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_2^2) - (C_{12}p_1p_2)^2},$$

$$\gamma_2 = \frac{(C_{11}p_2^2 - C_{12}p_1p_2)(C_{22}p_1^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_1^2) + (C_{12}p_1p_2)(C_{22}p_1^2 - C_{12}p_1p_2)}{(C_{22}p_1^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_1^2)(C_{11}p_2^2 + (C_{11}C_{22} - C_{12}^2)\eta_1\sigma_2^2) - (C_{12}p_1p_2)^2}.$$

The correlated influences are shown by a numerical example, *NE*9, along with Figs. 3(e) and (f).

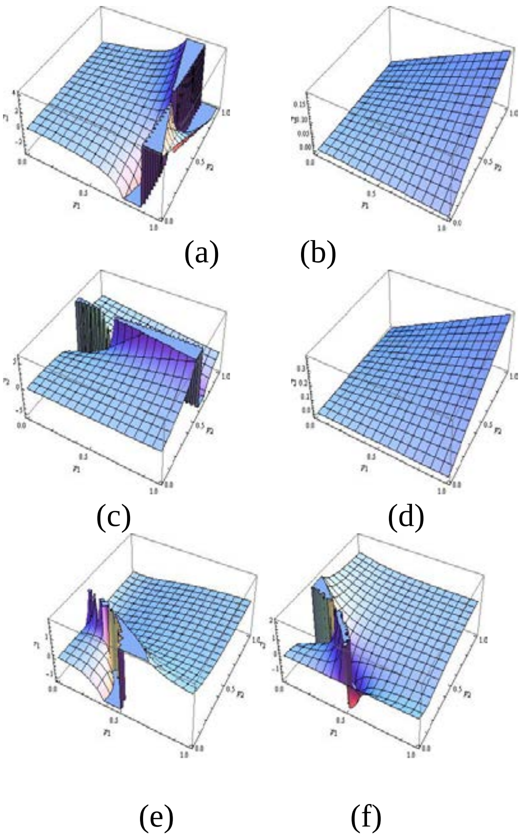

Figure 3. γ_1,γ_2 as a function of both p_1 and p_2 (when $C_{12} > 0$) for (a) and (b) *NE*7,(c) and(d)*NE*8,and(e) and (f) *NE*9, (*NE*: numerical example).

4. Concluding remarks

The variables of emphasis on scheduling have been incorporated into a multi-task principal-agent model for designing the optimal incentive scheme for two highly structured tasks of employees, the routine job and the information security policies compliance. The role of emphasis on scheduling in the optimal incentive scheme has been analyzed under the conditions that independent, complementary and substitutional relationships exist between the effort costs of the two tasks, and that the observability of the task outcomes is different. The influences of the variables of emphasis on scheduling on the incentive intensities applied to the two tasks have been simulated and discussed, and the corresponding incentive tactics are presented. The two-task incentive scheme can be used to motivate an employee to allocate appropriately her efforts for the two highly structured tasks performed in the same time period. Finally, it should be noted that the other facets of the temporal orientation such as time urgency may also influence employee's efforts allocation. Their influences on the allocation of employee's efforts will be studied in our future work.

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