The Effect of Incentive Contracts on Learning and Performance
Author(s): Geoffrey B. Sprinkle
Reviewed work(s):
Published by: American Accounting Association
Stable URL: http://www.jstor.org/stable/248615
Accessed: 28/12/2011 04:15

Your use of the JSTOR archive indicates your acceptance of the Terms & Conditions of Use, available at http://www.jstor.org/page/info/about/policies/terms.jsp

JSTOR is a not-for-profit service that helps scholars, researchers, and students discover, use, and build upon a wide range of content in a trusted digital archive. We use information technology and tools to increase productivity and facilitate new forms of scholarship. For more information about JSTOR, please contact support@jstor.org.
The Effect of Incentive Contracts on Learning and Performance

Geoffrey B. Sprinkle
Indiana University

ABSTRACT: This paper reports the results of an experiment that examines how incentive-based compensation contracts compare to flat-wage compensation contracts in motivating individual learning and performance. I use a multiperiod cognitive task where the accounting system generates information (feedback) that has both a contracting role and a belief-revision role. The results suggest that incentives enhance performance and the rate of improvement in performance by increasing both: (1) the amount of time participants devoted to the task, and (2) participants' analysis and use of information. Further, I find evidence that incentives improve performance only after considerable feedback and experience, which may help explain why many prior one-shot decision-making experiments show no incentive effects. Collectively, the results suggest that incentives induce individuals to work longer and smarter, thereby increasing the likelihood that they will develop and use the innovative strategies frequently required to perform well in complex judgment tasks and learning situations.

Key Words: Incentives, Learning, Effort and performance, Cognitive task.

Data Availability: Data gathered in this study are available from the author upon request.

I. INTRODUCTION

This study investigates how incentive-based compensation contracts compare to flat-wage compensation contracts in motivating individual learning and performance. I investigate learning in the context of a multiperiod production setting where the...
accounting system generates information that has both a contracting role and a belief-revision role. My primary objective is to examine whether and how incentive-based contracts improve individuals' performance in situations where they can learn from feedback and experience.

Many managerial decisions are multiperiod and dynamic in nature. For example, decisions concerning all aspects of production are typically repeated as firms attempt to maximize profits in the face of changing conditions. Repeated decisions provide an opportunity for learning, and evidence suggests that organizational performance increases when individuals learn to use firm assets effectively and efficiently (Hayes et al. 1988; Horngren et al. 2000).

A fundamental objective of managerial accounting systems is to facilitate learning and performance (Atkinson et al. 1997, 4). Specifically, managerial accounting information has two major potential uses in multiperiod settings. First, managerial accounting information enables individuals to revise their beliefs, and thus to improve firm productivity by making better-informed decisions. Second, managerial accounting information can be used in compensation contracts to motivate individuals to improve firm productivity. Economic (agency) theory suggests that these two uses of managerial accounting information are not independent. For learning to occur, theory suggests that (1) individuals must be able to use the information (feedback) provided for belief-revision purposes to improve future productivity, and (2) the firm must use incentive contracts to motivate individuals to exert effort and use feedback to improve performance.

Relatively few studies (Arkes et al. 1986; Ashton 1990; Hogarth et al. 1991) have examined the extent to which monetary incentives motivate effort and performance in multiperiod cognitive tasks that allow learning from feedback. In contrast to economic theory, the results of these studies indicate that performance-based contracts do not improve, and sometimes even degrade, learning and performance (at least relative to flat-wage contracts).1 These findings suggest that incentives may divert a decision maker’s attention away from how best to do the task, and to instead focus on how well he is doing on the task (Humphreys and Revelle 1984; Ashton 1990; Wood et al. 1990; Hogarth et al. 1991). In essence, incentives may create a dysfunctional preoccupation with extrinsic rewards that discourage risk-taking, creativity, and innovation (Kohn 1993). If this is the case, then in learning situations the firm need only provide managers with information for belief-revision purposes; there may be no further gains from using information for contracting (i.e., motivational) purposes.

However, this prior experimental research has not considered settings where the incentive contract is optimal and/or there is a significant role for learning. As a result, it is unclear whether the results generalize to environments where both: (1) the information provided for belief-revision purposes helps individuals improve productivity, and (2) the incentive contract motivates individuals to maximize total expected profit.

The current study examines how incentive-based compensation contracts, compared to flat-wage compensation contracts, affect individual learning and performance in an experiment that has a unique and optimal decision rule. Learning plays a significant role in the experiment, and the incentive-based contract theoretically motivates participants to (1) exert first-best effort, and (2) use feedback to make choices that maximize total expected profit. The results indicate that participants receiving the incentive-based contract spend more time

---

1 More generally, recent reviews of judgment and decision-making studies show that incentives frequently do not improve performance (e.g., Jenkins et al. 1998; Bonner, Hastie, Sprinkle, and Young 1999; Bonner and Sprinkle 1999; Camerer and Hogarth 1999).
on the task than participants receiving the flat-wage contract, and that this effort difference remains constant over the course of the experiment. Participants receiving the incentive-based contract also perform better on the task than participants receiving the flat-wage contract. However, there are no statistically significant differences in performance between compensation conditions for the first 15 of the 60 experimental periods. Moreover, the dynamics indicate that the positive difference in performance between compensation conditions increases significantly over the course of the experiment. Finally, incentives significantly enhance performance even after controlling for differences in the amount of time participants spend on the task.

These results have several important implications. First, the results suggest that incentives can increase the rate of improvement in performance and accelerate the learning curve. This finding is of particular interest given firms’ recent emphasis on continuous improvement and enhancing productivity. Second, the results indicate that incentives improve performance by motivating individuals to increase both the duration and intensity of their effort. Thus, incentives not only motivate individuals to work longer on a task, but the evidence also suggests that incentives enhance the quality of attention individuals devote to the task. This in turn enables individuals to develop better strategies that help them make decisions more consistent with profit maximization.

Third, the results suggest that the quality of the information provided for belief-revision purposes and the form of the incentive contract may help explain why prior multiperiod decision-making experiments do not detect any incentive effects. The results also suggest that many one-shot individual choice and decision-making experiments may fail to detect incentive effects because participants lack feedback and experience with the task.

In sum, my findings suggest that the belief revision and contracting uses of managerial accounting information are not independent. Belief-revision feedback information enabled participants to learn (improve performance), but the magnitude of this learning increased when the information provided by the accounting system was also used for contracting purposes.

The rest of this paper is organized into four sections. The next section develops the hypotheses, and Section III presents the experimental design. Section IV reports the results of the analyses. The results are summarized and discussed in Section V.

II. BACKGROUND AND HYPOTHESES

Prior experimental research has investigated whether incentives motivate individuals to improve their performance in multiperiod tasks that encompass learning from feedback. This research has found that, relative to flat-wage contracts, incentive contracts do not improve, and sometimes even degrade, learning and performance (Arkes et al. 1986; Ashton 1990; Hogarth et al. 1991). In a probabilistic task, Arkes et al. (1986) found that participants in an incentive condition made fewer accurate judgments than participants in a no-money condition. In a multiple-cue probability learning experiment, Ashton (1990) found that professional auditors’ bond-rating performance in an incentive plus feedback condition was not significantly better than performance in a condition with feedback alone. In a single-cue probability learning study, Hogarth et al. (1991) manipulated both exactingness (the steepness of the loss function) and incentives. They found no significant main effects for incentives and only one significant exactingness-by-incentives disordinal interaction. These findings, as well as many other experiments that show no incentive effects (see, e.g., Bonner, Hastie, Sprinkle, and Young 1999), led some to suggest that financial incentives have little effect on the results of decision-making experiments (Thaler 1986; Tversky and Kahneman 1986; Dawes 1988; Libby and Lipe 1992).
There are a number of explanations for the lack of incentive effects on multiperiod tasks that involve learning from feedback (and, more generally, decision-making experiments that find no incentive effects). First, in complex cognitive and learning tasks, incentives may divert a decision maker’s attention away from how best to do the task, and to instead worry about how well he is doing on the task (Baumeister 1984; Humphreys and Revelle 1984; Kanfer and Ackerman 1989; Ashton 1990; Wood et al. 1990; Hogarth et al. 1991; Kohn 1993). Second, extrinsic rewards may undermine an individual’s intrinsic motivation to perform a task (Weiner 1980; Deci and Ryan 1985; Kohn 1993; Vogl 1994).

Prior research posits that intrinsic motivation promotes more creative and flexible decision making than extrinsic motivation (Deci and Ryan 1985; Skaggs et al. 1992). Thus, extrinsic incentives may actually impair performance on the very tasks they were intended to motivate (Freedman et al. 1992). Finally, if individuals are motivated to work hard even when they expect no personal reward (Simon 1991), compensation’s conventional role of motivation may be less important than its role in informing individuals of their responsibilities (White 1985).

There are, however, alternative explanations for prior research’s general failure to detect incentive effects. Prior research has not satisfied many of the incentive or informational conditions that theory suggests are important for incentive contracts to enhance effort and performance in multiperiod settings. First, the incentive contracts chosen by Arkes et al. (1986), Ashton (1990), and Hogarth et al. (1991) have rather weak incentive properties. For example, Arkes et al. (1986) and Ashton (1990) used tournament incentive schemes, and Hogarth et al. (1991) used a discontinuous incentive scheme. These contracts can induce inconsistent, high-variance strategies and outcomes (Friedman and Sunder 1994). Second, in all three studies the value of feedback provided to participants was unclear. For example, in Arkes et al. (1986), feedback contained no additional information beyond the priors initially given to participants; in Ashton’s (1990) study, feedback did not foster learning as auditors’ later judgments were not more accurate than their earlier ones (Heiman 1990); in Hogarth et al. (1991), participants were not aware of how decisions and outcomes translated into earnings. Thus, the relatively weak forms of the incentive contracts and the relatively poor quality of the feedback may account for the failure to detect performance-enhancing incentive effects.

To determine whether the results of prior research might be attributable to economic factors, the current study examines the effects of incentive-based and flat-wage compensation contracts on individual learning and performance in an experiment where: (1) the information provided for belief-revision purposes can help participants improve future average productivity, and (2) the form of the incentive contract should motivate individuals to choose the effort levels and make decisions that maximize total expected profit. In my experimental setting, participants must (implicitly) solve a dynamic programming problem. The feedback provided for belief-revision purposes allows participants to make better-informed action choices. In addition, the incentive-based contract theoretically motivates participants to implement the first-best strategy over action choices, and to use feedback to maximize total expected performance. This leads to the first two hypotheses (stated in alternative form):

**H1:** Compared to individuals receiving a flat-wage contract, individuals receiving an incentive-based contract will exert more effort on the task.

**H2:** Compared to individuals receiving a flat-wage contract, individuals receiving an incentive-based contract will perform better on the task.
Hypotheses 1 and 2 are stated in terms of an overall average effect. As explained next, I also expect the performance superiority induced by the incentive condition to increase over the course of the experiment.

As noted previously, many “one-shot” (single-period) individual choice and decision-making experiments find no incentive effects.\(^2\) One explanation for their failure to detect incentive effects is that when individuals first perform a task, they may not understand how to perform it well (Awasthi and Pratt 1990; Libby and Lipe 1992; Bonner, Hastie, Young, Hesford, and Gigone 1999). In this case, individuals receiving incentive contracts may in fact exert more effort on the task (Awasthi and Pratt 1990). However, if initial performance on the task is not effort-sensitive (e.g., because individuals lack the statistical intuition or an understanding of the task requirements), it is unlikely that the study will detect an incentive effect (Awasthi and Pratt 1990; Libby and Lipe 1992).

Feedback and experience can help individuals learn and thereby improve their performance, suggesting that performance on a cognitive task is likely to become more effort-sensitive over time. For example, feedback and experience can help individuals eliminate many reasoning errors, and evidence indicates that as individuals repeat decisions, their behavior frequently becomes more consistent with economic predictions (Slonim 1994; Camerer 1995; Roth and Erev 1995). More generally, Horngren et al. (2000, 344) and Hilton et al. (2000, 493) explain that individuals’ efficiency and effectiveness generally improve as they become more familiar with a task.

Prior research therefore suggests that performance in the early periods of a cognitive task may not differ between compensation conditions. However, as participants receive feedback and gain experience, the difference in performance will likely increase if participants receiving the incentive-based contract continually exert more effort than participants receiving the flat-wage contract. Moreover, I expect incentives to not only increase the amount of time individuals spend on the task, but also to increase the intensity of effort and thus the quality of attention they devote to the task (Bonner and Sprinkle 1999). In turn, individuals who continually analyze their feedback and refine their strategies are likely to perform better over time (Locke and Latham 1990). This leads to the third hypothesis (stated in alternative form):

\[ \text{H3: The performance superiority induced by the incentive-based contract will increase over the course of the experiment.} \]

### III. EXPERIMENTAL DESIGN

**Task Description**

In the experiment, participants made a production (output quantity) decision for a single product in each of 60 periods. The 60 decision-making periods were partitioned into 12 independent “trials” where each trial consisted of five consecutive periods. In each period \((t)\) of the experiment, the participant's output decision \((a_t)\), combined with a state of nature \((s)\), jointly determined profit \((\pi_t)\), \(\pi_t = f(a_t, s)\). Table 1 lists the possible output choices (quantities), states of nature, and profit for each possible output choice and state of nature combination for each period of the experiment.

---

TABLE 1
Profit (in Points) from Each Possible Output Quantity and State of Nature Combination
for Each Period of the Experiment

<table>
<thead>
<tr>
<th>State of Nature (s)</th>
<th>Output Quantity (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>18</td>
<td>5</td>
</tr>
<tr>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
</tr>
</tbody>
</table>

*Participants in the experiment made an output quantity decision in each of 60 periods. The 60 decision-making periods were partitioned into 12 independent trials, where each trial consisted of five periods in which the state of nature did not change from period to period. For any given trial, each of the 20 states of nature occurred with equal probability.

Participants in the experiment received the following information about aᵣ, s, and f(aᵣ, s). First, in each period of the experiment participants knew that aᵣ ∈ {1,2,3,...,18,19,20}, s ∈ {1,2,3,...,18,19,20}, and f(aᵣ, s) for all possible output choices and states of nature. Second, participants were informed that s did not change over a five-period interval. That is, for experimental purposes a “trial” consisted of five periods in which the state of nature, s, did not change from period to period. In each trial, participants made five consecutive output choices; one choice for each period. Third, participants knew that at the start of each trial, each of the 20 states of nature occur with equal probability (i.e.,
s \sim U[1,20] \text{ discrete}). Finally, at the end of each period t, t \in \{1,2,3,4,5\}, within each trial, participants knew they could observe feedback regarding the realized profit, \(\pi_1, \ldots, \pi_t\), for each output decision that they had made up to and including period t.

The realized profit information, \(\pi(\cdot)\), has two potential uses: (1) belief revision, and (2) contracting. For any period t within each trial a participant can condition output choice \(a_t\) on the outcomes of all prior output choices, \(\pi_1, \ldots, \pi_t\). Thus, within each trial, participants can use the realized outcomes of all prior output decisions to update their beliefs regarding the expected profit of alternative (future) output decisions. In addition, the realized profit can be used in incentive contracting since \(\pi(\cdot)\) is informative about the participant’s output choices.

This experiment incorporates two forms of learning. First, participants can learn about the state of nature within each of the 12 trials of the experiment.\(^3\) Second, participants can increase their efficiency and effectiveness on the task by learning from experience (or learning-by-doing) across the 12 trials.

**First-Best Strategy\(^4\)**

A participant’s period 1 information set in each of the 12 trials of the experiment can be defined as \(\eta_1 = (1.21)\) since \(s \sim U[1,20]\). Therefore, the probability that a participant’s first period output choice, \(a_1\), will be less than or equal to \(s\) equals \([(21-a_1)/20]\). Let \(\pi^p(a)\) denote the possible positive payoff from the \(a\)’th output choice. Then, the participant’s one-period maximization problem can be defined as follows:

\[
\max_{1 \leq a_1 \leq 20} \left[ \text{prob}(a_1 \leq s|\eta_1) \cdot \pi^p(a_1) \right].
\]

The value of this one-period maximization problem is 30 points, which corresponds to an output choice of 11. However, this is not the solution to the multiperiod problem participants faced in the experiment; this solution is outlined below.

Table 1 shows that when \(a_1 \leq s\) the payoff from that output choice is positive (\(\pi^p\)). However, when \(a_1 > s\) the payoff from that output choice is 0. Thus, depending on \(\pi_1\), the participant’s new information set equals either \(\eta_2 = (a_1, 21)\) when \(a_1 \leq s\) (\(\pi_1 = \pi^p\)) or \(\eta_2 = (1, a_1)\) when \(a_1 > s\) (\(\pi_1 = 0\)). Therefore, the participant’s belief about \(s\) at \(t = 2\) will be defined by a new uniform distribution over \(\eta\). Specifically, \(s \sim U[a_1, 20]\) when \(\pi^p\) results from \(a_1\), or \(s \sim U[1, a_1 - 1]\) when 0 results from \(a_1\). As a result, the participant’s second period output choice will be \(a_2 \in [a_1, 20]\) or \(a_2 \in [1, a_1 - 1]\). More generally, for any \(a_t\), the participant’s information set can be defined, based on the \(t-1\) previous periods, as \(\eta_t = (a_{Ht}, a_{Lt})\) where \(a_{Ht}\) is the highest output choice with a positive payoff and \(a_{Lt}\) is the lowest output choice with a 0 payoff. This implies that \(a_t \in [a_{Ht}, a_{Lt}]\) for all \(t\) since the participant knows that \(s\) satisfies \(a_{Ht} \leq s < a_{Lt}\).

To maximize total expected profit in each trial, a participant must therefore condition period t’s output choice on the number of periods remaining \((5 - t + 1)\) and on any information collected about \(s\) up to that period \((\eta_t)\). Accordingly, participants must implicitly solve a finite-horizon dynamic programming problem in each trial. Let \(V_t(\eta_t, 5 - t + 1)\) be the value of this dynamic program before choice \(t\) given the information set \(\eta_t\) and

\(^3\) The information in Table 1 combined with feedback regarding the realized profit allows participants to increase their expected profit performance in each trial relative to a randomization strategy by approximately 120 points (130 percent).

\(^4\) While the term “first-best” often indicates the absence of informational asymmetries between parties that result in welfare losses, I use the term to refer to the optimal solution of the n-period maximization problem.
5 - t + 1 output choices remaining. Then, for any period t, the participant should choose a_t to:

\[
\max_{a_{t+1} \leq a_t < a_{t+2}} [(\text{prob}(a_t \leq s|\eta_t) \cdot \pi^p(a_t)) + E_c(V_{t+1}(\eta_{t+1}, 5 - t))].
\] (2)

I used a computer program to find both the value of this dynamic program and the first-best sequence of output choices. The first-best sequence of output choices and the resulting payoff (profit) appear in Table 2 for all possible state of nature (s) realizations.5

**Risk Preferences and Effort Measurement**

I measure performance as the total profit a participant earned from making output decisions in each trial. Table 1 lists the profit points per output decision. Because profit is stochastically related to output decisions, the setting is multiperiod, and there is a role for learning, I induced risk-neutral preferences to eliminate any consumption smoothing effects and to facilitate the derivation of the first-best decision rule.

I used the Roth and Malouf (1979) and Berg et al. (1986) methods to induce risk-neutral preferences. The points participants earned in each period were converted to a probability of winning the preferred monetary prize in a two-prize lottery. Specifically, for each of the 60 periods of the experiment, I conducted a lottery using tickets numbered sequentially from 1 to 100. If the number of points the participant earned was greater than or equal to the number on the ticket drawn, the participant received $0.50 for that period; otherwise, the participant received $0.00 for that period.

I measure effort as the amount of time a participant spent making output decisions in each trial. Using time as a measure of effort is consistent with the general definition of effort in the agency literature (Baiman 1982) because the participant controls his allocation of time between nontask (leisure) activity and task (work) activity, and the participant derives disutility from time spent on the task. Previous studies have used time to proxy for cognitive effort, and have shown that time is highly correlated with other psychological measures of effort (Bettman et al. 1990).

In addition to the cost in time to develop a strategy, participants also incurred costs in time to implement any strategy that used realized profit information. To see the result of their output choice for each period within a trial (i.e., \(\pi_1, \ldots, \pi_4\)), participants had to

---

5 In the dynamic (five-period) maximization problem, 14 is the optimal first-period choice. In the one-period maximization problem, 11 is the optimal choice. This difference arises because having choices in later periods can affect choices in earlier periods. Consider the following two-period example, adapted from Amershi et al. (1985). There are three possible states of nature, denoted \(s_1, s_2, s_3\), and three possible actions, denoted \(a_1, a_2, a_3\). States of nature occur with equal probability and the decision maker is risk-neutral. Payoffs for each state of nature and each action follow:

<table>
<thead>
<tr>
<th>s_1</th>
<th>a_1</th>
<th>a_2</th>
<th>a_3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\pi_1)</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(\pi_2)</td>
<td>3</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>(\pi_3)</td>
<td>3</td>
<td>60</td>
<td>105</td>
</tr>
</tbody>
</table>

In a one-period setting choosing \(a_2\) yields an expected profit of 40, whereas choosing \(a_1\) yields an expected profit of 35. However, in a two-period setting choosing \(a_2\) in period 1 yields a two-period expected profit of \(2/3[60 + 60] + 1/3[3] = 81\), whereas choosing \(a_1\) in period 1 yields a two-period expected profit of \(1/3[105 + 105] + 1/3[60] = 90\). Thus, the choice problem does not decompose (Amershi et al. 1985), and when learning can occur, choosing the higher action is more informative for subsequent decisions.
TABLE 2
First-Best Sequence of Output Choices and the Resulting Total Profit (in Points)
for Each State of Nature\(^a\)

<table>
<thead>
<tr>
<th>State of Nature (s)</th>
<th>Output Choices ((a_i))</th>
<th>Total Profit (in Points)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a_1)</td>
<td>(a_2)</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>7</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>11</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>12</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>13</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>15</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>16</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>17</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>18</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>19</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>20</td>
<td>14</td>
<td>16</td>
</tr>
</tbody>
</table>

Average = 212.50

\(^a\) To maximize profit in each of the 12 trials of the experiment, participants must (implicitly) solve a five-period dynamic programming problem. In this five-period maximization problem, 14 is the optimal first-period output choice. The optimal second-period output choice is either nine (when realized profit = 0 points) or 16 (when realized profit = 80 points). Similarly, the period 3 output choice will depend on the realized profit observed from period 2, and so on. The total profit (in points) is obtained using the payoff information in Table 1.

request feedback. Upon this request, \(\pi_1, \ldots, \pi_1\) was displayed for ten seconds, and participants could not accelerate this process. Thus, the cost to fully implement the first-best strategy ranged from 20 to 40+ seconds because it is necessary to examine feedback at least two times and at most four times (see, e.g., Table 2).
I induced effort aversion by exacting opportunity costs for time spent on the task. Participants had only three minutes to complete each trial. In addition to receiving points for making output choices in each period, participants earned 15 points per minute (five points per 20 seconds, etc.) for finishing each trial before this three-minute time limit. At the end of each trial, these points were converted to a probability of winning an additional $0.50 using the lottery procedures outlined above.

Compensation Contract Manipulation

I manipulated the compensation contract as a between-subjects factor with two levels, incentive-based and flat-wage. Participants in the incentive-based condition received the number of profit points they generated from their output choice in each period. This simple sharing-rule contract provides strong incentives because the participant is both risk-neutral and a residual claimant (Laffont and Tirole 1993). Participants in the flat-wage condition received 40 points each period regardless of the number of profit points generated from their output choice in that period. The 40 points per period approximated the expected number of points participants would earn under the first-best decision rule. As a result, the expected compensation for completing the task was approximately equal between compensation conditions.

The optimal strategy for participants receiving the incentive-based contract is the first-best strategy because the benefits exceed the costs of implementing the first-best strategy for all possible states of nature. That is, the incentive-based contract should motivate participants to implement the first-best strategy (detailed in Table 2) over the five output choices in each trial and, consequently, use feedback to maximize the total expected points in each trial. The optimal strategy for participants receiving the flat-wage contract is not the first-best strategy. Rather, the optimal strategy under the flat-wage contract is a randomization or myopic strategy because the flat-wage contract combined with the opportunity costs provides participants an incentive to shirk (i.e., never request feedback information or use the information provided in Table 1).

Participants and Procedures

Forty undergraduate (sophomore and above) business students from a large midwestern university participated in the experiment. Participants were randomly assigned to one of the two compensation conditions (incentive-based or flat-wage), with an equal number assigned to each condition.

---

6 The specific calculation was: \([180\text{ seconds allowed} - (the\ participant's\ time\ to\ complete\ the\ trial\ in\ seconds)] \times (0.25\ points\ per\ second)\), rounded up to the nearest point. The 15 points per minute was derived as follows. First, I determined that the benefit to requesting feedback was smallest in the choice sequence 14-9-6-4-1 (see Table 2). If profit of “0” occurs after a choice of six, two periods remain under the first-best strategy. The expected benefit of requesting feedback in period 4 is \([3/5 \times 5 + (2/5) \times 20] \approx 3\) points. Since it costs ten seconds to receive this expected three-point benefit, a 15-point-per-minute opportunity cost just makes requesting feedback preferred. Thus, the theoretical solution to the dynamic programming problem is the same with or without the costs of acquiring feedback information. An alternative approach would have been to select a cost large enough so that under some realized states of nature it would not always have been profitable to request feedback. I chose to employ the former approach to ensure that the predicted performance difference between compensation conditions was as large as possible, and also to ensure that exerting effort was costly to participants.

7 While I have described the task as a single-person setting with an exogenous contract, the problem could be reformulated, without loss of generality, as a standard principal-agent problem (e.g., the hidden information models analyzed by Holmstrom and Milgrom [1987]).
Each session began with the experimenter reading the instructions. The experimenter first informed participants that their task was to earn profit points by choosing a production quantity in each of 60 decision-making periods. Next, the experimenter described the compensation scheme. The instructions indicated that participants receiving the incentive-based contract would earn the number of profit points generated from their output choice, and that participants receiving the flat-wage contract would earn 40 points in each decision-making period. The method for converting these points to cash was then described in detail.

The experimenter explained that the number of profit points earned in a particular decision-making period depended on: (1) the production quantity participants selected, and (2) the state of nature the computer selected. The experimenter also distributed several "profit sheets," each containing the information shown in Table 1. Thus, participants could determine the number of profit points they would earn for each of the 20 output choices (columns), given each of the 20 states of nature (rows) that the computer might choose. Next, the experimenter explained that a trial consisted of five consecutive decision-making periods where the computer selected the same state of nature. Thus, participants knew that the state of nature would remain the same throughout the five periods of each trial.

Participants also learned that during each period within a trial they could see the results of their previous output choices. This feature allowed participants to learn about the state of nature the computer selected for the trial, and thereby allowed participants to update their beliefs regarding the expected profit of alternative future output choices. However, examining feedback was costly. Participants had to request realized profit information, and this feedback information was displayed for ten seconds per request.

After describing the feedback procedures, the experimenter informed participants that they had a maximum of three minutes to complete each trial. In addition, participants were informed that: (1) they would earn 15 points per minute (five points per 20 seconds, etc.) for each minute that they finished before three minutes, and (2) these points were separate from the points they earned from making output choices. To help participants keep track of their time, a computerized clock display counted down from 3:00 minutes to 0:00 minutes.

Participants then learned that the entire experiment consisted of 12 trials (i.e., 12 trials \( \times 5 \) periods per trial = 60 decision-making periods) and that each trial was separate and independent. Participants were informed that the computer would select 12 states of nature in the experiment, one for each trial, and that these states of nature had been determined in advance. The 12 states of nature were selected in advance to maintain consistency and comparability between sessions and compensation conditions. In addition, to make comparisons between the early (first three) and later (last three) trials of the experiment (e.g., to test H3), the last three states of nature were set the same as the first three states of nature. However, within trials 1–3 and 10–12, the order of these states of nature was randomized.

After listening to the instructions, participants answered a brief quiz regarding the instructions. Participants then started the first trial. Participants made their first-period output choice for trial 1, decided whether to examine the result of this output choice, made their second-period output choice for trial 1, decided whether to examine the result of this output choice, and so on, until they made five output choices. At the end of each of the 12 trials, all participants received a summary of: (1) their output choice for each period in the trial, (2) the profit points earned from that output choice, (3) their point earnings for each period of the trial, (4) the time they took to complete the trial, and (5) the points they received for finishing at that time.
Participants then converted their points to cash. Participants drew a total of six lottery tickets (with replacement); one ticket for the points they earned in each of the five periods in the trial and one ticket for the points they earned from finishing the trial before three minutes. Thus, for each of the five output choices in a trial, participants could earn $0.50 ($2.50 per trial). For finishing each trial before three minutes, participants could earn an additional $0.50.

After participants chose lottery tickets for each trial, the experimenter entered these numbers into the computer. Participants then received a summary of their earnings for that particular trial as well as a summary of their total earnings for all trials up to and including the most recent trial. Next, the clock was reset to three minutes and all participants started the next trial. At the end of the experiment (approximately 90 minutes), participants received their earnings in cash (average earnings were $15.00).

IV. RESULTS

Hypothesis 1

Hypothesis 1 posits that participants receiving the incentive-based contract will exert more effort on the task than participants receiving the flat-wage contract. I measure effort via the amount of time participants spent on the task. Figure 1 and Table 3 present the average time (in seconds) spent on the task by compensation condition and by trial. For each trial, participants receiving the incentive-based contract spent more time on the task than participants receiving the flat-wage contract.

I tested H1 using an ANOVA with time (in seconds) per trial as the dependent variable, compensation condition as the between-subjects factor, and trial as the within-subjects (repeated-measures) factor. Hypothesis 1 would be supported by a significant compensation condition main effect, where the mean time spent per trial is higher for participants receiving the incentive-based contract.

Table 3 documents that the average time spent on the task per trial was 62.02 seconds for participants in the incentive-based condition and 49.01 seconds for participants in the flat-wage condition. Table 4 indicates that the compensation condition main effect is statistically significant (F = 10.87, p < 0.01). Therefore, participants receiving the incentive-based contract spent significantly more time on the task than participants receiving the flat-wage contract. Table 4 also reveals a significant main effect for trial (F = 54.69, p < 0.01). Table 3 and Figure 1 show that in both compensation conditions, the average time spent on the task declined over trials (both trends are significant at p ≤ 0.01). Beyond this, no other effects were significant at p ≤ 0.05.

Hypothesis 2

Hypothesis 2 posits that participants receiving the incentive-based contract will earn more profit (i.e., perform better) than participants receiving the flat-wage contract. Figure 2 presents the average profit participants earned by compensation condition and by period within trial, with the bar representing the profit for period five under the first-best strategy. Table 5 presents the average profit by compensation condition and by trial, as well as profit under the first-best strategy by trial. For each trial, and generally for each period within a

---

8 Repeated-measures ANOVA requires that the differences for all treatment combinations be homogeneous (Huyhn and Feldt 1970; Rouanet and Lepine 1970) and that the degree of covariation between all pairs of treatment scores be the same (Box 1954). Violations of these assumptions lead to overstated degrees of freedom in the F-ratio with a maximum reduction in the degrees of freedom to one in the numerator and n₁ – 1 in the denominator. When necessary, the significance levels reported in the paper are adjusted using the Geisser and Greenhouse (1958) technique.
The 60 decision-making periods were partitioned into 12 independent trials, where each trial consisted of five periods in which the state of nature did not change from period to period. Participants under the incentive-based contract received the number of profit points they generated from their output choice in each of the five periods within a trial. Participants under the flat-wage contract received 40 points for each of the five periods within a trial regardless of the number of profit points generated from their output choices.

In trial, participants receiving the incentive-based contract earned more profit than participants receiving the flat-wage contract.

I tested H2 using an ANOVA with total profit (in points) per trial as the dependent variable, compensation condition as the between-subjects factor, and trial as the within-subjects (repeated-measures) factor. Hypothesis 2 would be supported by a significant compensation condition main effect where the mean profit per trial is higher for participants receiving the incentive-based contract.

Table 5 shows that the average profit per trial was 203.48 points for participants in the incentive-based condition and 168.88 points for participants in the flat-wage condition.
### TABLE 3
Average Time (in Seconds) Participants Spent on the Task by Compensation Condition and by Trial

<table>
<thead>
<tr>
<th>Trial&lt;sup&gt;b&lt;/sup&gt;</th>
<th>State of Nature (s)&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Incentive-Based Contract</th>
<th>Flat-Wage Contract</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>109.21</td>
<td>90.58</td>
<td>18.63**</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>79.20</td>
<td>64.00</td>
<td>15.20***</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>70.33</td>
<td>52.90</td>
<td>17.43***</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>60.49</td>
<td>47.67</td>
<td>12.82**</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>57.82</td>
<td>45.63</td>
<td>12.19**</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>55.27</td>
<td>42.23</td>
<td>13.04**</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>59.85</td>
<td>43.94</td>
<td>15.91***</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>56.68</td>
<td>42.48</td>
<td>14.20***</td>
</tr>
<tr>
<td>9</td>
<td>11</td>
<td>46.18</td>
<td>41.65</td>
<td>4.53</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>49.49</td>
<td>42.36</td>
<td>7.13*</td>
</tr>
<tr>
<td>11</td>
<td>14</td>
<td>47.25</td>
<td>39.16</td>
<td>8.09**</td>
</tr>
<tr>
<td>12</td>
<td>17</td>
<td>52.49</td>
<td>35.57</td>
<td>16.92***</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>62.02</td>
<td>49.01</td>
<td>13.01***</td>
</tr>
</tbody>
</table>

*, **, and *** indicate significance at p < 0.10, p < 0.05, and p < 0.01 in one-tailed tests using time-per-trial as the dependent variable, respectively.

<sup>a</sup> Participants under the incentive-based contract received the number of profit points they generated from their output choice in each of the five periods within a trial. Participants under the flat-wage contract received 40 points for each of the five periods within a trial regardless of the number of profit points generated from their output choices.

<sup>b</sup> The 60 decision-making periods were partitioned into 12 independent trials, where each trial consisted of five periods in which the state of nature did not change from period to period.

<sup>c</sup> The realized state of nature (see Table 1).

Table 6 indicates that the compensation condition main effect is statistically significant (F = 11.21, p < 0.01). Therefore, participants receiving the incentive-based contract earned more profit than participants receiving the flat-wage contract. Table 6 also reveals a significant trial main effect (F = 222.95, p < 0.01). This effect is significant by design since the state of nature and, consequently, the maximum profit attainable, changes from trial to trial. Finally, Table 6 indicates that the compensation condition-by-trial interaction is significant, indicating that the effect of compensation condition differed across trials. Follow-up tests (shown in Table 5) indicated that the compensation condition simple effect was significant (at p ≤ 0.05) in trials 4, 6, 8, 9, 10, 11, and 12. Although H2 was supported, there is no statistically significant difference in the profit performance between compensation conditions over the first three trials (smallest p > 0.27); it is not until the end of trial
Hypothesis 3 posits that the difference in the profit performance between participants receiving the incentive-based contract and participants receiving the flat-wage contract will increase over the course of the experiment. To test this hypothesis, I collapsed the data into two performance measures for each participant, an average profit per trial for trials 1–3 and an average profit per trial for trials 10–12. Recall that the states of nature for trials 1–3 were the same as the states of nature for trials 10–12. Although the order of these states of nature was randomized within trials 1–3 and trials 10–12, this allows me to make intertemporal comparisons in performance over the same set of state realizations.

Figure 3 presents the average profit participants earned per trial by compensation condition for trials 1–3 and 10–12. As shown in Figure 3 (and Table 5), participants in the incentive-based condition earned an average profit of 213.00 points per trial over trials 1–3, which is only 15.33 more points than the average profit of 197.67 points participants in the flat-wage condition earned per trial over trials 1–3. Consistent with H3, however, the average profit difference between compensation conditions is much greater in the last three trials than in the first three trials. Participants in the incentive-based condition earned an average profit of 251.58 points per trial over trials 10–12, which is 53.00 points higher

4 (period 20) that a marginally significant difference emerges (t = 1.39, p < 0.10, one-tailed).9

**Hypothesis 3**

*ANOVA on the Amount of Time (in Seconds) Participants Spent on the Task per Trial*

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F*</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compensation Conditionb</td>
<td>20,298.46</td>
<td>1</td>
<td>20,298.46</td>
<td>10.87</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Subject(Compensation Condition)</td>
<td>70,972.13</td>
<td>38</td>
<td>1,867.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trialc</td>
<td>115,435.25</td>
<td>11</td>
<td>10,494.11</td>
<td>54.69</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Compensation Condition × Trial</td>
<td>2,122.75</td>
<td>11</td>
<td>192.98</td>
<td>1.01</td>
<td>&lt; 0.44</td>
</tr>
<tr>
<td>Trial × Subject(Compensation Condition)</td>
<td>80,211.09</td>
<td>418</td>
<td>191.89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* The Subject(Compensation Condition) mean square is the appropriate error term for Compensation Condition (the between-subjects effect). The Trial × Subject(Compensation Condition) mean square is the appropriate error term for the within-subjects effects.

b I manipulated Compensation Condition as a between-subjects factor with two levels, incentive-based and flat-wage. Participants in the incentive-based condition received the number of profit points they generated from their output choice in each of the five periods within a trial. Participants in the flat-wage condition received 40 points for each of the five periods within a trial regardless of the number of profit points generated from their output choices.

c I manipulated Trial as a within-subjects factor with 12 levels, 1–12. Participants in both compensation conditions completed 12 independent trials, where each trial consisted of five consecutive and related periods. Participants made a separate output choice for each of the five periods in a trial, and the state of nature did not change over these five-period intervals.

9 These results are based on four separate ANOVAs conducted with the data from trial 1, trials 1 and 2, trials 1–3, and trials 1–4, using the dependent and independent variables employed to test H2.
FIGURE 2
Average Profit (in Points) Participants Earned on the Task by Compensation Condition and by Period Within Trial

![Graph showing average profit earned by participants under different compensation conditions across periods.](image)

*Participants under the incentive-based contract received the number of profit points they generated from their output choice in each of the five periods within a trial. Participants under the flat-wage contract received 40 points for each of the five periods within a trial regardless of the number of profit points generated from their output choices. All participants made output-quantity decisions in each of 60 periods. The 60 decision-making periods were partitioned into 12 independent trials, where each trial consisted of five periods in which the state of nature did not change from period to period. The bar represents the profit under the first-best strategy for period 5 (see Table 2).*

than the average profit of 198.58 points participants in the flat-wage condition earned per trial over trials 10–12.

To formally test the third hypothesis, I conducted an ANOVA with the average points per trial for trials 1–3 and 10–12 as dependent variables, compensation condition as the between-subjects factor, and trial (at two levels, 1–3 or 10–12) as the within-subjects (repeated-measures) factor. Table 7 indicates that the compensation condition-by-trial interaction is statistically significant (F = 5.95, p < 0.02). Therefore, the relative superiority of the profit performance of participants receiving the incentive-based contract increased over the course of the experiment.\(^{10}\)

\(^{10}\) Prior research has not used time-based opportunity costs to induce effort aversion. To examine whether this manipulation affected participants’ effort levels and output choices, I ran an additional experiment with the same task and setting, but participants were not compensated for finishing each trial before three minutes. Twenty new participants were assigned to each compensation condition. The results support all hypotheses (one-tailed p < 0.10, 0.02, and 0.01 for H1, H2, and H3, respectively), indicating that the results are robust with respect to the presence of time-based opportunity costs.
TABLE 5
Average Profit Performance (in Points) by Compensation Condition and by Trial

<table>
<thead>
<tr>
<th>Trial&lt;sup&gt;b&lt;/sup&gt;</th>
<th>State of Nature (s)&lt;sup&gt;c&lt;/sup&gt;</th>
<th>First-Best Strategy&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Incentive-Based Contract (1)</th>
<th>Flat-Wage Contract (2)</th>
<th>Difference (1) – (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>460.00</td>
<td>321.25</td>
<td>295.00</td>
<td>26.25</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>90.00</td>
<td>64.25</td>
<td>58.75</td>
<td>5.50</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>320.00</td>
<td>253.50</td>
<td>239.25</td>
<td>14.25</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>135.00</td>
<td>148.50</td>
<td>124.50</td>
<td>24.00**</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>90.00</td>
<td>85.75</td>
<td>67.75</td>
<td>18.00*</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>225.00</td>
<td>215.50</td>
<td>176.50</td>
<td>39.00**</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>40.00</td>
<td>40.00</td>
<td>31.00</td>
<td>9.00*</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>460.00</td>
<td>346.00</td>
<td>278.00</td>
<td>68.00***</td>
</tr>
<tr>
<td>9</td>
<td>11</td>
<td>225.00</td>
<td>212.25</td>
<td>160.00</td>
<td>52.25**</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>90.00</td>
<td>89.00</td>
<td>68.00</td>
<td>21.00**</td>
</tr>
<tr>
<td>11</td>
<td>14</td>
<td>320.00</td>
<td>299.25</td>
<td>226.00</td>
<td>73.25***</td>
</tr>
<tr>
<td>12</td>
<td>17</td>
<td>460.00</td>
<td>366.50</td>
<td>301.75</td>
<td>64.75***</td>
</tr>
</tbody>
</table>

Average 243.00 203.48 168.88 34.60***

<sup>*</sup>, **, and *** indicate significance at p ≤ 0.10, p ≤ 0.05, and p ≤ 0.01 in one-tailed tests using profit (in points) per trial as the dependent variable, respectively.

Participants under the incentive-based contract received the number of profit points they generated from their output choice in each of the five periods within a trial. Participants under the flat-wage contract received 40 points for each of the five periods within a trial regardless of the number of profit points generated from their output choices.

The 60 decision-making periods were partitioned into 12 independent trials, where each trial consisted of five periods in which the state of nature did not change from period to period.

The realized state of nature (see Table 1).

Based on the first-best sequence of output choices and the resulting total profit in points earned from these output choices for each realized state of nature (see Table 2).

The Association between the Duration of Effort and Performance

Tables 3–7 present evidence that incentive-based contracts increase effort and performance. I now assess the extent to which the incentive-based contract affected performance through its effect on the duration of effort (Libby and Lipe 1992). I conducted an ANCOVA with total points per trial as the dependent variable, compensation condition and trial as independent variables, and time (per trial) and the time-by-compensation condition interaction as covariates. The results of this ANCOVA indicate that the time main effect is

11 While researchers often use ANCOVA to control a concomitant variable, it is also useful for analyzing a single quantitative dependent variable and both quantitative and qualitative (categorical) independent variables. As discussed in Wildt and Ahtola (1978, 8), this is analogous to performing a regression analysis with dummy variables.
not statistically significant in explaining performance ($F = 1.23, p < 0.27$). The time-by-compensation condition interaction, however, is statistically significant ($F = 46.63, p < 0.01$), indicating that the effect of the duration of effort on performance differed between compensation conditions.$^{12}$

Since the time-by-compensation condition interaction was significant, I examined the simple effect of time at each level of compensation condition. In the incentive-based condition, the simple effect of time is significant ($F = 53.49, p < 0.01$), and the total time spent on the task is negatively correlated with total performance ($p = -0.73, p < 0.01$). In the flat-wage condition, the simple effect of time is also significant ($F = 10.77, p < 0.01$), but the total time spent on the task is positively correlated with total performance ($p = 0.45, p < 0.05$).

The negative relation between the amount of time spent on the task and performance in the incentive-based condition can be partially understood as follows. The first-best strategy calls for participants to use feedback to change their output choices up to some period $t$, and then maintain the same output choice from period $t$ to period 5 (see Table 2). However, if participants “oversearch,” then time increases (to examine the extra feedback), yet profit will likely decrease if participants increase their output choice beyond the optimal point. For example, assume that the realized state of nature is 17 (as in trials 1 and 12). Next, assume that two participants choose 14 as their first-period output. In period 2, after requesting feedback in period 1, both participants increase their output choice to 16. In periods 3, 4 and 5, the first participant follows the first-best strategy and stays with an

\[ 12 \text{ An alternative measure of effort is the number of times participants requested feedback. However, the correlation between the time spent per trial and the number of times participants requested feedback was 0.73 (p < 0.01), so this alternative measure of effort led to qualitatively similar inferences.} \]
FIGURE 3
Average Profit (in Points) Participants Earned on the Task per Trial by Compensation Condition for Trials 1–3 and 10–12a

Participants under the incentive-based contract received the number of profit points they generated from their output choice in each of the five periods within a trial. Participants under the flat-wage contract received 40 points for each of the five periods within a trial regardless of the number of profit points generated from their output choices. The 60 decision-making periods were partitioned into 12 independent trials, where each trial consisted of five periods in which the state of nature did not change from period to period. To examine differences in performance between compensation conditions over the course of the experiment, I designed the experiment so that the first three states of nature were the same as the last three states of nature. However, within trials 1–3 and 10–12, the order of these states of nature was randomized.

output choice of 16. In period 3, however, the second participant chooses 19, requests feedback and realizes that profit was 0 at that choice; he then goes back to an output choice of 16 in periods 4 and 5. Thus, the first participant spent 20+ seconds on the task (because he examined feedback two times) and earned 460 profit points, whereas the second participant spent 30+ seconds on the task (because he examined feedback three times) and yet earned only 365 profit points.

Further analysis suggests that many participants in the incentive-based condition did engage in such “oversearching” behavior. While the first-best strategy predicts that participants will request feedback 32 times in the experiment, participants in the incentive-based
condition examined feedback an average of 38.40 times. This “oversearching” behavior likely explains the negative relation between the duration of effort and performance in the incentive-based condition.

The positive relation between the amount of time spent on the task and performance in the flat-wage condition is likely attributable to the opposite phenomenon. While some participants receiving the flat-wage contract “oversearched” in relation to the first-best strategy, several participants in this condition made mostly random or myopic choices as theory predicts (i.e., “undersearched” in relation to the first-best strategy).13 For these latter participants, the amount of time spent on the task is close to zero because they rarely requested feedback and, as a consequence, they generally earned much less profit than participants who examined and used feedback information. The positive relation between the duration of effort and performance in the flat-wage condition is thus largely attributable to the differences between: (1) participants who infrequently requested feedback and, as a result, performed poorly, and (2) participants who frequently requested and used feedback and, as a result, improved their performance on the task.

13 Participants in the flat-wage condition examined feedback only an average of 28.50 times (compared to the first-best strategy prediction of 32), with 25 percent (five) of these participants requesting feedback less than 15 times. In general, participants in the flat-wage condition continually “undersearched” across trials and moved away from the first-best strategy, but toward the theoretical prediction for this condition (i.e., no searching), by the end of the experiment. In the incentive-based condition, participants continually “oversearched” across trials, although they moved toward the first-best strategy prediction by the end of the experiment.

### TABLE 7

ANOVA on the Average Amount of Profit (in Points) Participants Earned on the Task per Trial for Trials 1–3 and Trials 10–12

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>(F^a)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compensation Condition(^b)</td>
<td>23,347.22</td>
<td>1</td>
<td>23,347.22</td>
<td>7.33</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Subject(Compensation Condition)</td>
<td>120,996.52</td>
<td>38</td>
<td>3,184.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial(^c)</td>
<td>7,801.24</td>
<td>1</td>
<td>7,801.24</td>
<td>6.55</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>Compensation Condition × Trial</td>
<td>7,093.88</td>
<td>1</td>
<td>7,093.88</td>
<td>5.95</td>
<td>&lt; 0.02</td>
</tr>
<tr>
<td>Trial × Subject(Compensation Condition)</td>
<td>45,285.41</td>
<td>38</td>
<td>1,191.72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) The Subject(Compensation Condition) mean square is the appropriate error term for Compensation Condition (the between-subjects effect). The Trial × Subject(Compensation Condition) mean square is the appropriate error term for the within-subjects effects.

\(^b\) I manipulated Compensation Condition as a between-subjects factor with two levels, incentive-based and flat-wage. Participants in the incentive-based condition received the number of profit points they generated from their output choice in each of the five periods within a trial. Participants in the flat-wage condition received 40 points for each of the five periods within a trial regardless of the number of profit points generated from their output choices.

\(^c\) The 60 decision-making periods were partitioned into 12 independent trials, where each trial consisted of five periods in which the state of nature did not change from period to period. To examine differences in performance between compensation conditions over the course of the experiment, I designed the experiment so that the first three states of nature were the same as the last three states of nature (although within trials 1–3 and 10–12, the order of these states of nature was randomized). To test for intertemporal differences in performance between compensation conditions, I collapsed the data into two performance measures for each participant, an average profit (in points) per trial for trials 1–3 and an average profit (in points) per trial for trials 10–12. In this ANOVA, Trial is a within-subjects factor with two levels, 1–3 or 10–12.
Collectively, the relations between the duration of effort and performance in each compensation condition are consistent with participants deriving both intrinsic and extrinsic rewards from the task. Subsequent analysis suggests that participants receiving the flat-wage contract likely received some intrinsic rewards from exerting effort on the task. However, in the absence of extrinsic rewards, the resulting effort is likely insufficient to maximize performance. Therefore, in the flat-wage condition the effort/performance observations tend to be in the region where performance is increasing in effort. On the other hand, the presence of both intrinsic and extrinsic rewards may have led participants in the incentive-based condition to choose an effort level beyond the point at which their monetary reward (measured performance) is maximized. Therefore, in the incentive-based condition the effort/performance observations tend to be in the region where performance is decreasing in effort.

Finally, while the overall association between the amount of time spent on the task and performance on the task is not statistically significant, spending additional time on the task tended to improve performance later in the experiment. Across compensation conditions, the correlation between the total time spent on the task and performance on the last six trials is 0.26, p < 0.06 (similar results hold for the last three trials and the last trial). Thus, working longer on the task did not necessarily pay off in the short-run, but it did enable participants to develop strategies for better performance in the long-run, consistent with the performance interaction shown in Figure 3.

The Effect of Incentives on Performance After Controlling for the Duration of Effort

While the current study measures effort via the amount of time spent on the task, effort may vary both in duration and intensity (Kanfer 1990; Libby and Lipe 1992). If incentives enhance performance even after controlling for the amount of time spent on the task (duration of effort), then it can be inferred that incentives also improved performance by increasing the intensity of effort.

To examine the effect of incentives on performance after controlling for the duration of effort, I added both time (per trial) and the time-by-compensation condition interaction as covariates to the model used to test H2. The compensation condition main effect remains statistically significant (t = 1.89, p < 0.05). Further analysis indicates that performance is higher under the incentive-based contract, even after controlling for the amount of time spent on the task. Therefore, the experiment's results suggest that incentives enhanced performance not only by increasing the amount of time devoted to the task, but also by improving the quality of attention participants devoted to the task and, consequently, their analysis and use of information.

Additional Analysis

Learning within a Trial

Figure 2 shows that in both compensation conditions, average profit performance increased from period 1 to period 5 within each of the 12 trials. A paired t-test indicates that profit performance increased significantly (at p ≤ 0.05) from period 1 to period 5 in 8 of the 12 trials in the flat-wage condition (trials 1, 3, 4, and 9 are the exceptions) and in 11 of the 12 trials in the incentive-based condition (trial 3 is the exception).

14 Kanfer (1990) suggests that effort intensity captures the amount of attention an individual devotes to a task during a fixed amount of time. Similarly, Libby and Lipe (1992) suggest that effort intensity refers to how hard an individual works, while effort duration refers to how long an individual works.
I expected this result in the incentive-based condition because these participants should request feedback information to update and improve their output choices over periods within each trial. For the flat-wage condition, however, the results are inconsistent with the theoretical prediction. For participants receiving the flat-wage contract, a random or myopic strategy is optimal because these participants have an incentive to perform the task as quickly as possible, and not to request or use information for belief-revision purposes. So, their period 1 profit performance should not differ from their period 5 profit performance. However, many participants in the flat-wage condition do not follow this strategy. Moreover, participants receiving the flat-wage contract earned an average of 168.88 points per trial, well above \( p < 0.01 \) the expected profit under a random strategy of 92.81 points per trial (given the realized states of nature). Given the economic incentives in the flat-wage condition, this result further suggests that many of these participants were intrinsically motivated to perform well on the task. This finding is also consistent with prior assertions that individuals derive utility from work activities (e.g., Deci and Ryan 1985; Holmstrom and Milgrom 1991; Simon 1991).

Figure 2 also shows that the average profit difference between participants receiving the incentive-based contract and participants receiving the flat-wage contract is higher in period 5 (an average difference of 8.14 points) than in period 1 (an average difference of 2.29 points) for ten of the 12 trials (trials 3 and 6 are the exceptions). A repeated-measures ANOVA, conducted on a trial-by-trial basis with the points per period for periods 1 and 5 within each trial, indicates, however, that the compensation condition-by-period interaction is statistically significant (at \( p \leq 0.05 \)) in only three of the 12 trials (trials 5, 7, 10). This provides some evidence of differences in learning between compensation conditions within a trial (the lack of significance in other trials is partly due to variability across participants in the period-by-period profit performance within each trial).

**First-Best Choices**

Fewer than 1 percent of participants’ output choice sequences in each trial were consistent with the first-best sequence. In the incentive-based condition, four of the 240 (20 participants \( \times \) 12 trials) output choice sequences were consistent with the first-best sequence. In the flat-wage condition, none of the output choice sequences were first-best. This result was partially driven by participants’ initial (period 1) output choice in each trial. The average first-period output choice (standard deviation) was 10.96 (2.31) and 10.60 (3.42) in the incentive-based and flat-wage conditions, respectively; recall that the first-best first-period output choice is 14. A repeated-measures ANOVA using the first-period output choice as the dependent variable revealed no significant differences in first-period output choices between compensation conditions, either overall or across trials. Moreover, participants’ first-period output choices did not differ significantly from the optimal choice in the one-period maximization problem (i.e., 11).

Given the information set generated by a participant’s first-period choice, however, it is possible to calculate the first-best strategy for the remaining four choices. When period 2, 3, 4, and 5 output choices are conditioned on the first-period choice, 74 (31 percent) of the output choice sequences in the incentive-based condition were consistent with the first-best strategy; 26 in trials 1–6 and 48 in trials 7–12. In the flat-wage condition, only 28 (12 percent) of the output choice sequences were consistent with the first-best strategy; nine in trials 1–6 and 19 in trials 7–12.\(^{15}\) Overall, these results indicate that: (1) conditioned on

\(^{15}\) The period 3, 4, and 5 output choices can be conditioned on the period 1 and 2 output choices, etc. In both conditions, participants’ output choice sequences became more optimal as t went from 1 to 5.
the first-period output choice, participants receiving the incentive-based contract developed strategies more consistent with the first-best strategy than participants receiving the flat-wage contract, and (2) participants’ output choices generally became more consistent with the first-best sequence over the course of the experiment.

**Dominated Choices**

Notice from Table 1 that 11 of the 20 output choices are dominated.\(^\text{16}\) I included the dominated choices to see if participants learned not to select dominated alternatives (Cooper et al. 1990). In the incentive-based condition, 26.33 percent of the participants’ choices were dominated; 33.33 percent in trials 1–6 and 19.33 percent in trials 7–12. In the flat-wage condition, 48.67 percent of the participants’ choices were dominated; 52.17 percent in trials 1–6 and 45.17 percent in trials 7–12. A repeated-measures ANOVA using the percentage of dominated choices as the dependent variable indicated significant main effects for both compensation condition and trial (both p’s < 0.01). Beyond this, no other effects were significant at p ≤ 0.05. Therefore, participants receiving the incentive-based contract made fewer dominated choices than participants receiving the flat-wage contract, again suggesting that participants receiving the incentive-based contract employed a strategy more consistent with profit maximization.

V. SUMMARY AND DISCUSSION

This study provides experimental evidence regarding how incentive-based compensation contracts compare to flat-wage compensation contracts in motivating individual learning and performance. The experiment’s results support the hypothesis that participants receiving the incentive-based contract spend more time on the task than participants receiving the flat-wage contract. In contrast to previous multiperiod experimental research (e.g., Arkes et al. 1986; Ashton 1990; Hogarth et al. 1991), but consistent with theory, participants receiving the incentive-based contract also performed better on the task than participants receiving the flat-wage contract. However, the incentive-based contract induced better performance only after the first 15 of the 60 experimental periods. Finally, incentives significantly enhanced performance even after controlling for the duration of effort (amount of attention), suggesting that incentives also increased the intensity of effort (quality of attention).

This study makes a number of contributions. First, the results provide an explanation for prior studies’ failure to find incentive effects in decision-making experiments that examine learning from feedback (e.g., Arkes et al. 1986; Ashton 1990; Hogarth et al. 1991). My results suggest that individuals receiving an incentive-based contract are likely to perform better than individuals receiving a flat-wage contract if: (1) the form of the incentive contract motivates profit maximization, and (2) the feedback provided for belief-revision purposes helps individuals make better decisions. Thus, concerns that performance-based monetary incentives increase pressure and discourage risk-taking, creativity, and innovation may not be justified.

Second, the results suggest that incentive-based compensation contracts increase the rate of learning and accelerate the learning curve (Levy 1965; Teplitz 1991). Given recent emphasis on continuous improvement and enhancing productivity (e.g., Atkinson et al. 1997; Hilton et al. 2000; Horngren et al. 2000), firms are likely to embrace factors that

---

\(^\text{16}\) Output choices 2, 5, 7, 8, 10, 12, 13, 15, 17, 18, and 20 are dominated. For example, output choices 17 and 18 are dominated by output choice 16. All three choices have the same possible profit (95 points), but output choice 16 minimizes the risk of earning this profit.
motivate employees to use resources more effectively and efficiently. Evidence that incentive-based compensation contracts appear to promote learning suggests that using accounting information for contracting can help firms gain a competitive advantage. This may explain why organizations are increasingly linking pay to performance (Wall Street Journal 1999).

Third, the results help reconcile conflicting prior evidence in the incentive-contracting literature. Evidence that monetary incentives increase effort and performance is consistent with the results of experiments where the task is more physical than cognitive (e.g., Young and Lewis 1995; Bailey et al. 1998; Bonner, Hastie, Sprinkle, and Young 1999), but inconsistent with the results of many experiments where the task is purely cognitive (e.g., Kohn 1993; Bonner and Sprinkle 1999). My study’s results indicate that initial performance on a cognitive task may not be highly sensitive to the increased effort induced by incentives, but subsequent improvements in performance are more likely to depend on motivation. Thus, experience and feedback may be necessary before incentives improve performance on more complex judgment tasks.

Evidence that the positive difference in profit performance between participants receiving the incentive-based contract and participants receiving the flat-wage contract increases significantly over the course of the experiment may also help explain why, relative to prior experimental research, archival empirical research more frequently reports a positive relation between pay and performance (e.g., Prendergast 1999). That is, in contrast to experimental studies, archival empirical studies typically use performance measures that reflect decisions over a relatively long period of time.

Finally, incentives not only increase the duration of effort but they also appear to increase the intensity of effort. Even after controlling for the increased time spent on the task, incentives still improved performance. This finding, in conjunction with the supplemental analyses, provides evidence that incentives improve individuals’ analysis and use of feedback information and encourage them to develop strategies to maximize performance. Thus, in addition to motivating individuals to work longer, incentives also appear to motivate individuals to work smarter.

Overall, the results suggest that the belief revision and contracting uses of managerial accounting information are not independent. Belief-revision feedback information enabled participants to learn, but the magnitude of this learning increased when participants had more incentive to learn. While the study’s general conclusions are consistent with economic theory, the dynamics regarding the process and rate of learning indicate that considerable feedback and experience with the task were necessary for the incentive-based contract to improve performance.

Like all research, this study is subject to limitations. I examined the effect of incentives on individual learning and performance using only one type of task and one type of incentive scheme. Accountants in practice and academe, however, are interested in the determinants of performance in a variety of tasks, including production and clerical tasks, memory tasks, judgment tasks, choice tasks, and problem-solving and reasoning tasks. Further, many different types of incentive compensation schemes are used in practice and are of interest to accounting researchers, including quota and budget-based schemes, piece-rate schemes, profit-sharing schemes, and tournament schemes. Finally, accounting researchers are interested not only in individual learning, but also in learning in workgroups and teams. Future research might investigate whether the results of this study generalize to other types of tasks, compensation contracts, and learning situations.

The study’s results suggest other possibilities for further inquiry. For example, this study considered a single, one-dimensional task. However, individuals often perform multiple tasks or a single task with multiple dimensions (Holmstrom and Milgrom 1991;
Feltham and Xie 1994). In such situations, incentive-based compensation serves both a motivational role and a role in directing individuals’ effort and attention among their various responsibilities. Holmstrom and Milgrom (1991) demonstrate analytically that when the ability to measure performance varies across tasks, a flat-wage contract may be optimal. However, this result hinges on the assumption that individuals derive utility from work activities. The effort and performance results I obtained suggest that individuals receiving the flat-wage contract derived some pleasure from working. Thus, an extension of the current study to a multi-task setting may prove interesting.

REFERENCES


