# The Use of Non-monotonic Contracts in a Single Period Game: An Experimental Investigation

Timothy Flannery

*Missouri State University*
*Department of Economics*
*901 S National Ave*
*Springfield, MO 65897*

Stephen Roberts

*Kentucky Wesleyan College*
*3000 Frederica St*
*Owensboro, KY 42301*

**Abstract**

This paper explores whether laboratory students design non-monotonic contracts when they are theoretically optimal in a simple principal-agent context. The principal constructs a contract for three possible outcomes, LOW, MEDIUM, and HIGH, and the agent observes the contract and responds with either an effort level of 0 or 12. Non-monotonic contracts that motivate high effort are optimal for principals because effort only affects the probability of LOW and MEDIUM outcomes. Our experiment has two treatments: one where principals interact with human agents and another with computer agents. Principals only select non-monotonic contracts with a frequency of 15% and 33% in each treatment, respectively. The results are consistent with concerns about equity and agent rationality.

*Keywords:* Non-monotonic Contracts, Principal-Agent Problems, Non-monotonicity, Experimental Economics, Contract Theory, Moral Hazard
JEL Classification: C91, D86, J31

## 1. Introduction

In the early years of FedEx, Frederick Smith saved the company from bankruptcy by taking $5000 to Las Vegas and winning $27,000 in the game of blackjack (Frock, 2009). Though some interpret this story as one of grit or demonstrating dedication to the firm at all costs, it sets an example that shareholders would be reluctant for their executives to follow. Encouraging such behavior puts bondholders at risk and creates a poor incentive to gamble

*Email addresses:* `tflannery@missouristate.edu` (Timothy Flannery), `stephen.roberts@kwc.edu` (Stephen Roberts)

everything when a firm nears financial ruin. Risks such as these are pervasive in the finance industry where one can earn large returns through risky investments. To mitigate this risk, firms might wish to design contracts that do not reward atypically high profit as that may indicate excessive risk. Such a contract exhibits non-monotonicity as agents earn more in the case of moderate earnings than high earnings. Given the potential of such contracts to improve welfare, their lack of use in the field seems perplexing.

This paper contributes to literature on labor markets and contracting as it is the first to explore whether principals construct non-monotonic contracts on their own accord which are theoretically optimal when given the opportunity. The experiment proposed in this paper improves on the existing experimental literature on non-monotonic contracts by providing several key additions. The design uses a simple setting with only one period, two choices for the agent (high or low effort), simple intuitive probabilities (one quarter and three quarters), and three possible outcomes: LOW, MEDIUM, and HIGH profit for the principal. In addition, we allow the principals to select any division of earnings for each outcome (with the restriction of no negative payout to the agent or the principal).[1] HIGH profit occurs in our experiment independent of agent effort; therefore, the theoretically optimal contract offers the agent more in the case of MEDIUM profit than HIGH profit, causing the optimal contract to exhibit non-monotonicity. Moreover, the design controls for factors such as risk preferences. Furthermore, our experiment controls for concerns about the rationality of the agent and other-regarding preferences by including two treatments: one with a human in the role of the agent and another with a computer in the role of the agent using a simple decision rule. Ultimately, we want to learn what type of contracts principals construct in this environment and whether the principal decides differently with a computer agent than a human one. We also want to see how agents respond to different contract structures, and the overall effect on efficiency, as this should inform us whether non-monotonic contracts, though theoretically optimal, are desirable in practice.

Several papers (Grossman and Hart, 1983; Innes, 1990; Hvide, 2002) have described various scenarios where non-monotonic contracts are optimal instead of more traditional monotonic or piece-rate contracts. In the simplest case, Grossman and Hart (1983) demonstrate non-monotonic contracts may be optimal when the highest outcome states are invariant to agent effort.[2] In this case, the highest outcomes provide no information about the effort of the agent, and the principal should not create contracts that reward these states. For instance, if an exogenous demand shock occurs in an industry, a firm may make record profits regardless of the efforts of its employees. Likewise, if misfortune or mismanagement lead one or more competitors to drop out of the market, a firm may make large profits that are not

[1] The design contrasts sharply from the scant prior research on the topic, Lukas (2007) and Brosig, Lukas, and Reichmann (2010), which only allowed the principal to select one of two predetermined contracts to offer and used more complicated two-period games with complex probabilities (such as 43%).

[2] In more complex environments where agents can choose both noise and effort, non-monotonic contracts may encourage more effort and less noise than traditional monotonic contracts. (Hvide, 2002)

primarily the result of the work of its own employees. Our experiment models the case where the highest outcomes are invariant to agent effort, and the theoretically best contract for the principal exhibits non-monotonicity. Though studied for decades, these contracts rarely occur in practice, and we hope this paper provides insight on why that may be the case.

If principals fail to offer non-monotonic contracts to computers agents, whose decision rule mimics that of a risk neutral profit maximizer, where they are clearly optimal, this indicates such contracts seldom exist in practice due to the inability of principals to conceive of them. However, even if principals construct non-monotonic contracts in the computer treatment, such contracts may also not occur in practice if agents react to them negatively. For example, agents might respond more favorably to theoretically suboptimal contracts, due to fairness or other-regarding preferences, and less favorably to non-monotonic contracts, which agents may perceive as unfair. In this case, principals might earn a higher payoff offering more standard contracts anyway. On the other hand, if principals offer the optimal contract often and agents respond in the predicted manner, this provides support for firms to offer such contracts when they are optimal, which could improve the profit for the firm, decrease the amount of risk in industries such as investment banking, and increase overall economic efficiency.

Our design allows the principal to control for factors such as risk and fairness. Because the principal may worry about agent risk preferences, there exists a non-monotonic contract that encourages the agent to choose high effort regardless of the agent's risk preferences which also theoretically provides the principal with more profit than any monotonic contract. To mitigate the effects of fairness from deterring agents away from non-monotonic contracts in our experiment, the contract that gives the principal and agent the highest amount of equally split surplus ex-ante (the difference in expected value) and that encourages the agent to choose high effort is also a non-monotonic contract. If fairness ex-post (the difference in the realized payment) matters to the agents, the optimal contract must be monotonic; however, agents earn more choosing low effort with such contracts. Because of these features of the experimental values, neither concerns about risk preferences of the agent nor concerns about fairness should alter the structure of the optimal contract (non-monotonic), unless agents care more about ex-post fairness than their total earnings.

In short, our experimental design allows us to test several key questions related to non-monotonic contracts. First, we can address the most basic question: if principals can write their own contracts, will they write non-monotonic contracts when they are theoretically optimal? Second, how do agents respond to different contracts in this environment? Finally, we test whether removing the concerns about agent rationality or other-regarding preferences by using computer agents alters the contract structure chosen by the principal. Our results show that a portion in both treatments offer non-monotonic contracts; however, principals offer non-monotonic contracts about twice as frequently in the treatment with computer agents. In the human treatment, principals offered theoretically non-incentivizing contracts which could be perceived as fair. Agents often responded favorably to these "fair" theoretically suboptimal contracts that compensate them for the cost of effort. Because human agents made decisions in this manner, principals earned more in the treatment with human agents even though they offered more theoretically optimal contracts in the treatment with computer agents. The theoretically suboptimal behavior of the human agents also caused efficiency to be roughly the same between treatments. Given the response of agents in our experiment and that a majority of contracts, even in the computer treatment, failed to have a non-monotonic structure, these results seem consistent with a lack of non-monotonic contracts in the field.

## 2. Background

A vast literature in economics examines both the theory and practice of optimal contracting, including recent laboratory experiments testing the predictions of contract theory. These experiments address two important questions: what kinds of contracts the principals offer and how the structure of a contract affects the choice of the agent. Keser and Willinger (2007) showed that the behavior of subjects, particularly when acting as principals, did not match the predictions of risk-neutral, profit-maximizing decision makers. In their experiment, principals showed a strong tendency to offer contracts that minimized the agent's risk and that offered agents a more even share of potential earnings. Similar subsequent research in contracting choices such as Fehr, Klein and Schmidt (2007) showed similar concerns for fairness and reciprocity in contracting. Reiss and Wolff (2014) test the behavior of subjects as agents in contract situations modeling entrepreneurial funding and show non-monotonic contracts can achieve greater effort and efficiency.

The results of experiments that look at the ability of principals to write theoretically optimal contracts are mixed. Two papers, (Berg et al. 1992, Epstein 1992), find that principals and agents very frequently play the subgame perfect Nash equilibrium theory predicts. Principals offer the expected profit maximizing contract, and agents respond according to the incentive scheme of the principal. Lukas (2007) shows that when offered a choice between an optimal non-monotonic contract and a non-optimal monotonic contract, principals generally offered the non-monotonic contract.[3] However, the author points out that since agents did not know the set of available contracts and only saw the chosen contract, principals may have been more willing to select the optimal non-monotonic contract. One limitation of each of these experiments is that they restricted the contracting options of the principal to a few selections by the experimenters.

[3]Brosig, Lukas, and Riechmann (2010) consider a similar setting to Lukas (2007), but they allow for an increased number of decision periods for the principal, allowing them to learn and adjust their behavior. Their results sharply contrast with Lukas (2007) regarding the predicted use of non-monotonic contracts; almost half the time principals choose the suboptimal, monotonic contract instead of the optimal, non-monotonic one.

In contrast, Keser and Willinger (2000) create an experiment similar to the one presented here, few outcomes and actions with the ability for unique contracting by the principal, but with a monotonic optimal contract. In their experiment, there are only two possible outcomes, and agents have two decisions: accept or reject the contract, and if they accept the contract, then select an effort level. They find that about 50% of contracts incentivize agents to engage in the high action. None of their contracts matched the exact theoretically optimal contract, and the vast majority offered agents significantly more than the theoretically optimal contract. Furthermore, about 30% of the time, agents, after accepting the contract, made an effort choice that was not consistent with risk-neutral profit maximization.

Other papers have begun to address why subjects in laboratory experiments often choose contracts that differ from those predicted by theory. For example, Anderhub, Gächter and Königstein (2002) showed the role that reciprocity could play in contracting decisions, with greater effort from agents rewarding more generous contracts from principals. In our experiment, we compare the principals' decisions when dealing with computer agents to their decisions when dealing with human agents in order to differentiate between possible causes for sub-optimal contracts. This treatment with computer agents allows us to estimate what proportion of principals can discern the optimal contract structure in a situation without concern for other-regarding factors such as fairness or agent rationality. In the human treatment, if principals offer fewer non-monotonic contracts, it demonstrates these other factors, such as rationality, reciprocity, or fairness, play a role in the choice of contract by the principal.

Several papers have demonstrated the value in using computer players in experiments to control for beliefs[4] or other-regarding preferences, as our paper does. For instance, Johnson et al. (2002) compares the bargaining behavior of subjects with computer opponents versus human opponents, in order to control for concerns about social preferences. Hoppe and Schmidtz (2015) use a treatment with computer buyers to test whether sellers offer different prices to the computer buyers than the human buyers in a simple adverse selection model, particularly in cases where the seller has the opportunity to extract all the surplus from the buyer. They find that sellers charge higher prices to computers than humans. Because many human buyers sometimes reject high prices at their own expense, charging a lower price than the theoretical optimal may give the sellers a higher profit. Hoppe and Schmitz (2013) find a similar result in a principal-agent game studying endogenous information acquisition.

[4]McKinney and Van Huyck (2007) and Bayer and Renou (2016) use computer opponents to control for concerns about the rationality or logical omniscience of a subject's opponent in games requiring iterated logic.

## 3. Optimal Contracting

The following table displays the cost of effort, the revenue to the principal, and the probabilities of each outcome contingent on effort from the contracting scenario used in the experiment. The rows represent the two possible effort choices of the agent, with respective costs of 0 and 12 to be paid out of an endowment of 20. The columns show the three possible outcomes, with the revenue to the principal for LOW, MEDIUM, and HIGH of 12, 36, and 48, respectively. From this revenue, the agent receives a payment after the realization of an outcome. Finally, the cells of intersection between the effort choice and the outcome display the probability of an outcome for a given effort choice. For example, the upper left cell has a value of $\frac{3}{4}$, meaning that the probability of the LOW outcome occurring given that the agent chose an effort level of 0 is $\frac{3}{4}$.

Table 1: **Probabilities**

| | **% of *LOW* Outcome Rev. = 12** | **% of *MEDIUM* Outcome Rev. = 36** | **% of *HIGH* Outcome Rev. = 48** |
|---|---|---|---|
| **Effort = 0** | 3/4 | 0 | 1/4 |
| **Effort = 12** | 0 | 3/4 | 1/4 |

A contract offered by the principal to the agent will be of the form $(x, y, z)$, where $x$ is the payment to the agent when the LOW outcome occurs, $y$ for the MEDIUM, and $z$ for the HIGH. Thus, the agent earns either $x + 20$ and $z + 20$ when low effort is chosen (because of the endowment) and $y+8$ and $z+8$ when high effort is chosen which costs the agent 12. The payoff to the principal, $(a, b, c)$ for the LOW, MEDIUM, and HIGH outcome respectively, will be the revenue of the outcome minus the payment to the agent: $12 - x = a$ if LOW occurs, $36 - y = b$ if MEDIUM occurs, and $48 - z = c$ if HIGH occurs.

Because the probability of the HIGH outcome occurring is the same, ($\frac{1}{4}$), regardless of which effort level is chosen by the agent, any payment of the principal to the agent for the HIGH outcome does not encourage the agent to take higher effort. We first examine the case of an agent who maximizes a Von Neumann-Morgenstern utility function, $U$. The incentive constraint for the agent to take higher effort (Effort = 12) is:

$$u(Effort = 12) : \frac{3}{4}U(y + 8) + \frac{1}{4}U(z + 8) \geq u(Effort = 0) : \frac{3}{4}U(x + 20) + \frac{1}{4}U(z + 20) \quad (1)$$

If $U$ is linear (a risk-neutral agent), the expected payment to the agent for the HIGH outcome is the same for both efforts levels, the incentive constraint simplifies to:

$$\frac{3}{4} * y - 12 \geq \frac{3}{4} * x \quad (2)$$

Restricting the principal to offering non-negative amounts for $x$, $y$, and $z$ means the principal will wish to select $x$ and $z$ equal to zero to most profitably incentivize the higher effort level.

Setting $x$ equal to zero in Equation 2 yields a value for $y$ of 16. The optimal contract for the principal to offer in order to incentivize the agent to take the higher effort choice is then $(0, 16, 0)$.[5]

If $U$ is sufficiently concave (a risk-averse agent), a principal may want to offer compensation to the agent so that the agent is never worse off by choosing high-effort. The least costly contract which achieves this yet still provides the agent with an incentive to choose high effort is the contract $(0, 16, 12)$, which is non-monotonic.

Agents may also care about maximizing total surplus or have concerns about equity. Thus, $U$ could also depend on $(a, b, c)$. If agents only care about total surplus, then choosing high effort is optimal regardless of the contract offered to them. In the case of an agent wanting to maximize total surplus but not wanting to risk losing any money for choosing high effort (in other words, an agent will respond favorably to a Pareto improvement), then the weakly monotonic contract (0,12,12) is optimal for the principal. Therefore, agents may choose high effort as long as they are compensated for the cost of effort. If agents care about equity, the optimal contract of the principal depends on whether they care about equity ex-ante (expected payoffs) or ex-post (realized payoffs). Suppose $U$ depends on the sum of two components, $v$ and $g$, where $v$ is a standard concave increasing function in the payment to the agent and $g$ measures inequality aversion; thus, $g$ decreases as the difference in expected payoffs (or possibly realized payoffs instead) increases while $g(0) = 0$. If agents only care about ex-ante fairness, the argument in $g$ would be the expected difference between the payments of the players, which for the high effort would be $\frac{3}{4}(y + 8) + \frac{1}{4}(z + 8) - (\frac{3}{4}b + \frac{1}{4}c)$, which can be minimized by setting $y = 16$ and $z = 14$.[6] Therefore, the contract (0,16,14) ensures the agent prefers to choose the high action in this scenario as each player earns an expected payoff of 23.5.

In the case where $g$ depends on ex-post payoffs, such as with the argument $|(y + 8) - b| + |(z + 8) - c|$ for $g$ (when high effort is chosen), then no contract minimizes $g$ and gives the agent a higher monetary payoff for high effort. The contract (0,14,20) minimizes $g$ if the agent chooses high effort (even though the agent earns less from choosing high with this contract). When MEDIUM occurs, both the principal and agent earn 22 and if HIGH occurs, both the principal and agent earn 28. If the agent chooses the low effort, the principal and agent earn 12 and 20 respectively when LOW occurs and 28 and 40 respectively when HIGH

[5] With this contract the agent is indifferent between the high effort and low effort choices; thus, this is the optimal contract assuming the agent chooses the high effort in this equilibrium. If the agent responds to $(0, 16, 0)$ by choosing low effort, then $(0, 17, 0)$ is the optimal contract for the principal.

[6] Though the high action creates a smaller difference in the expected payoffs with such a function than the low action under the contracts (0,16,12) and (0,16,13), the $g$ function may be asymmetric as in the Fehr-Schmidt model (1999) when $\alpha < \beta$; thus, the only way to guarantee the agent prefers the high action with such preferences is to offer (0,16,14).

occurs. Thus, agents must care more about ex-post fairness[7] than total earnings if they choose high effort in this scenario. Principals should only offer this contract if they believe agents have a strong preference for ex-post fairness as offering it risks a worse expected payoff than the null contract (0,0,0) for the principal when the agent chooses low effort (earnings of 16 for the contract (0,14,20) vs 21 for the null contract).

Given the experimental design, principals should offer agents non-monotonic contracts such as (0,16,0), (0,16,12), or (0,16,14); unless they strongly believe agents primarily care about ex-post fairness or only want to maximize total surplus as long as it is Pareto improvement, in which case they may earn more offering the monotonic contract (0,14,20) or (0,12,12). In the case the principal believes the agent has limited cognition or does not understand when to choose high effort, then offering (0,0,0) may be optimal.

## 4. Experimental Design

The experiment consisted of two treatments which differed in the type of agent interacting with the principal: Type (H) with human agents and Type (C) with computer agents. Both agent types used the same sequence of events and parameter values for the experiment. In each round of the experiment, the principal set a contract, $(x, y, z)$, with a different payoff to the agent for each of the three outcomes: LOW, MEDIUM, and HIGH. After the agent saw the contract she had been given by the principal, she chose between the two levels of effort, paying effort costs out of an endowment of 20 per round. Once the agent selects an effort level, an outcome was realized based on the distribution for the particular effort choice, and the principal and the agent received earnings based on the contract and the realized outcome. Earnings for the agents included the remaining endowment (20 if low effort is selected, 8 if high effort is selected). Both the principal and agent observed the payoffs of both players after each interaction. Final payoffs for the subjects were their earnings exchanged at a rate of 10 ECU = 1 USD, plus a $5 show up fee.

Table 1 shows the parameters of the experiment used in both treatments, which we selected for several key reasons. First, as mentioned earlier, the theoretically optimal contract that incentivizes high effort is non-monotonic: $(0, 16, 0)$. The contract $(0, 16, 0)$ gives the principal an expected payoff of 27, whereas the optimal contract that encourages low effort low (0,0,0) only gives the principal a payoff 21. Agents receive an expected payment of 20 to both contracts, (0,0,0) and (0,16,0). Though the optimal contract exhibits non-monotonicity, several monotonic contracts also induce the agent to choose high effort and give the principal a higher payment than $(0, 0, 0)$.[8]

[7]Alternatively, the agent could be motivated by positive reciprocity or guilt-aversion since the principal clearly expects the agent to choose high effort with such a generous contract.

[8]The weakly monotonic contract with the largest payment for the MEDIUM outcome that both induces high effort and gives the principal as much expected payoff as the null contract is (0,18,18). The contract with the largest payment for the HIGH outcome that both induces high effort and gives the principal as

Second, as shown in the previous section, the values used in the experiment allow for the principal to profitably incentivize high effort with contracts that mitigate concerns regarding risk-aversion and fairness. Principals can offer agents the contract $(0, 16, 12)$ to guarantee the agent recoups the cost of effort, which has an expected payoff of 23 for the agent and 24 for the principal, still greater than the principals payoff of 21 from (0,0,0). The contract $(0, 16, 14)$ incentivizes high effort and provides parties the same expected payoff of 23.5, alleviating concerns about ex-ante fairness. All other contracts that incentivize high effort and give the same ex-ante payoff to both subjects will also be non-monotonic.[9]

Finally, the cost consisted of a significant portion of the agents expected earnings in the experiment. Agents received an endowment each round of 20 ECUs, and the cost of the higher effort action was 12 ECUs. Since agents had to spend sixty percent of their endowment each period to take higher effort, the effort cost encouraged agents to think carefully about the contract they received.

Each session of the experiment ran for 8 periods, the first three unpaid practice periods followed by five paid periods of play. The number of rounds allowed subjects to become accustomed to an unfamiliar environment, while still keeping each paid round a significant portion of overall earnings. In Type (H), subjects were initially randomly assigned to the role of principal or agent and remained in the same role throughout. In Type (C), all subjects were in the role of a principal, and the computer selected choices for the agent. The computer selected whichever effort choice provided the highest expected payoff, with indifference leading to selection of high effort.[10]

In Type (H), the experiment randomly rematched principals and agents at the end of each round. Rematching enabled the principals to learn about the contracts without creating any reputational concerns. Agents in Type (H) received an endowment in each period of 20 ECUs, and chose to use either 0 or 12 of them to affect the likelihoods of the final outcomes. Agents did not have to agree to a contract, because they always had the option to use none of their endowment in a period by choosing the low level of effort if they found the contract unfavorable.

Before subjects began the practice rounds, they each received a printed sheet with instructions summarizing the experiment.[11] Once a subject logged into a computer, the computer

much expected payoff as the null contract is (0,16,24).

[9]All other such contracts would need to increase payment to the agent for the MEDIUM outcome and decrease payment for the HIGH outcome since the MEDIUM payment must exceed the LOW payment by at least 16 to induce high effort. For example, the contract (0,18,8) also splits the ex-ante surplus evenly and incentivizes high effort.

[10]The instructions informed principals in Type (C) of the decision rule of the computer agent.

[11]See Appendix for each set of instructions.

provided an additional set of instructions, specific to the subject's role, with interposed quiz questions to ensure each subject understood the design of the game.[12] The computer randomly generated a sample contract for subjects, both principals and agents, immediately before they began the experiment and demonstrated the payment each subject would receive, for both the high and low effort action with the given contract.

After completing the experiment, subjects answered a few survey questions.[13] In particular, principals in each treatment responded to a question on how they would behave differently if matched with a different type of agent: in Type (H) if they interacted with a computer agent instead and in Type (C) if they interacted with a human agent instead.

## 5. Hypotheses

The experiment tests the following hypotheses related to the use of non-monotonic contracts:

**Hypothesis 1.** *Principals will write contracts that pay the agents more in the MEDIUM outcome than in the HIGH outcome.*

Because the likelihood of the HIGH outcome does not depend on the effort choice of the agent, principals will not wish to pay for the HIGH outcome. Instead, principals will pay agents more for the MEDIUM outcome, because it provides clear proof that agents have selected higher effort.

**Hypothesis 2.** *The frequency of contracts exhibiting non-monotonic behavior will be higher when dealing with computer agents [Type (C)] than when dealing with human agents [Type (H)].*

Since principals do not need to worry about the rationality of agents and will not be motivated by fairness or reciprocity when dealing with computer agents, principals are more likely to write non-monotonic contracts in Type (C). This is particularly true if human agents care about the final distribution of the surplus (ex-post fairness) or total efficiency and respond favorably to theoretically suboptimal contracts they perceive as fair or that are a Pareto improvement over the null contract. In these cases, principals may offer contracts such as (0,14,20), (0,12,12) and others more frequently in the (H) treatment as opposed to non-monotonic contracts.

**Hypothesis 3.** *Principals will write contracts incentivizing* ***Effort=12*** *with greater expected payoff to agents when dealing with human agents [Type (H)] than when dealing with computer agents [Type (C)].*

[12] Please contact the authors if interested in the code for the instructions and interposed quiz.

[13] Please contact the authors for details.

Hypothesis 3 is based on prior experiments previously summarized that show a tendency towards fairness when principals write their own contracts (Fehr, Klein, and Schmidt, 2007; Keser and Willinger, 2000; Keser and Willinger, 2007). If kindness or reciprocity motivates principals, or if principals worry about risk-aversion or the ability of agents to interpret contracts, they may choose contracts that pay the agent more for the HIGH outcome.

## 6. Results

Type (H) had 50 subjects, 25 principals and 25 agents, and Type (C) had 40 subjects, all principals. Overall average earnings for the subjects were 14.85 USD: 5 USD show up fee and 9.85 average payoff from the experiment. Average session length was approximately 60 minutes for Type (H) and 45 minutes for Type (C). Subjects were students recruited at the University of Arizona, and all experimental sessions were conducted in the Economic Science Laboratory at the University of Arizona using SoPHIE software (Hendriks, 2012). The Graduate and Professional Student Council at the University of Arizona funded this project.

### *6.1. Hypotheses*

Hypothesis 1 stated that principals would pay more for the MEDIUM outcome than for the HIGH outcome. Table 2 presents the mean and median contract offers for the MEDIUM and HIGH outcomes during all rounds, all paid rounds (five rounds total), and the final three paid rounds. The median offers shows non-monotonic behavior regardless of rounds for Type (C) and in the final three paid rounds for Type (H) as predicted by theory. The average exceeds the median for the HIGH offers while the average is less than the median with MEDIUM offers indicating skews in opposite directions.

Table 2: **Contract Offers (in ECUs)**

| | **Type (H) MEDIUM offer** | **Type (H) HIGH offer** | **Type (C) MEDIUM offer** | **Type (C) HIGH offer** |
|---|---|---|---|---|
| **Mean - All Rounds** | 11.48 | 14.68 | 13.66 | 15.48 |
| **Mean - All Paid** | 10.6 | 13.33 | 12.44 | 13.46 |
| **Mean - Final 3** | 10.57 | 12.53 | 12.24 | 12.13 |
| **Median - All Rounds** | 12 | 12.5 | 15 | 14 |
| **Median - All Paid** | 12 | 12 | 15 | 12 |
| **Median - Final 3** | 12 | 10 | 15 | 10 |

The average HIGH offer exceeds the MEDIUM offer, contrary to our theoretic prediction, except in the final three rounds in Type (C). The primary cause comes from a few principals offering large amounts in the HIGH outcome, between 37-48, which is impossible in the MEDIUM outcome. Because HIGH offers can be so much larger, having means contrary to the predicted outcomes and medians in line with the predicted outcome is unsurprising. However, over time, principals reduced the amount of such large offers for the HIGH outcome from 10.7% in all rounds, to 6.7% in the paid rounds, to 4.1% in the final three rounds. Principals offered the most extreme HIGH offer of 48 a total of 25 times, but only 3 times in the final three rounds.

Table 3: **Contract Types**

| | **Peaked Non-Monotonic** | **Monotonically Increasing** | **Constant** | **Other** |
|---|---|---|---|---|
| **Type (H) All Rounds** | 15.5% | 59.5% | 21.0% | 4.0% |
| **Type (H) Paid Rounds** | 15.3% | 57.3% | 23.4% | 4.0% |
| **Type (H) Final 3 Rounds** | 14.7% | 54.7% | 25.3% | 5.3% |
| **Type (C) All Rounds** | 30.6% | 50.3% | 12.8% | 6.3% |
| **Type (C) Paid Rounds** | 32.5% | 46.0% | 15.5% | 6.0% |
| **Type (C) Final 3 Rounds** | 35.8% | 42.5% | 15.0% | 6.7% |

In the experiment, the only cases where the MEDIUM offer was greater than the HIGH offer was in strictly non-monotonic contracts. In Table 3, these are the Peaked Non-Monotonic contracts. As Table 3 demonstrates, the highest proportion of non-monotonic contracts occurred in the final three rounds of the computer treatment. Even in these last rounds, barely over a third (35.8%) of contracts had the non-monotonic property of the MEDIUM offer being greater than the HIGH offer.[14] This proportion is much lower in the human treatment (15.5% for all rounds, 14.7% for final 3 rounds). Round 4 in the computer treatment had the largest percentage of non-monotonic contracts at 45%. Thus, any test, such as a sign test using data at the individual level, fails to support the hypothesis that principals offer non-monotonic contracts a majority of the time.[15]

[14] In the last 3 computer treatment rounds, 35.83% had the MEDIUM offer greater than HIGH, 17.5% had them equal, and 46.67% had the HIGH offer greater than MEDIUM.

[15] Though this may seem inconsistent with Table 2, it is not. For example, consider the three contracts (0,1,2), (2,3,4), and (1,4,1). The median contract (1,3,2) is non-monotonic even though a majority of

Hypothesis 2 predicts that the usage of non-monotonic contracts will be higher in Type (C), with computer agents, than in Type (H), with human agents. As Table 3 shows, this indeed happened. In each selection of rounds (All, Paid, and Final 3), the percentage of non-monotonic contracts in Type (C) is roughly double the percentage in Type (H). Additionally, the two types trended in different directions: as the experiment continued, principals in Type (H) used fewer non-monotonic contracts (14.7% in the final 3 rounds compared to 15.5% for all rounds) while principals in Type (C) used more (35.8% in the final 3 rounds compared to 30.6% for the all rounds). The percent of non-monotonic in Type (C) exceeded that of the Type (H) in all eight rounds. Using Fisher's exact test to compare the percentages in the paid rounds, three out of five rounds are significantly different, including the final round.[16]

In Type (H), principals offered several monotonic contracts to agents that failed to theoretically incentivize effort but may be perceived as more "fair" and compensated the agent's cost of effort. We analyzed the amount of such contracts in each treatment.[17] In Type (H), 19.2% of such contracts were "fair" but not incentivizing in paid rounds compared to only 6.5% in Type (C). The percent of fair non-incentivizing contracts in Type (H) exceeded that of Type (C) in all paid rounds, with significance in the final three rounds.[18] In the final round, the difference was most extreme as 24% of contracts were "fair" but not incentivizing in Type (H) compared to 2.5% in Type (C).

Hypothesis 3 concerns the value of the incentivizing contracts offered to the agents in the two types. Table 4 presents the value beyond what was necessary to incentivize *Effort=12*, for all incentivizing contracts and for only non-monotonic incentivizing contracts for both types. Table 4 demonstrates that in comparing contracts that incentivize *Effort=12*, more surplus is given to human agents than to computer agents. We compare the extra surplus with the last incentivizing paid round contract each principal offered using a one-sided Mann-Whitney U test and find that principals offer significantly more to human agents than the computers (p=0.031). However, looking at only non-monotonic contracts that incentivize *Effort=12* displays no noticeable difference between the excess value offered to agents.

contracts are monotonic.

[16]Rounds 1, 4, and 5 were significantly different using a 1-sided Fisher's exact test with p-values of 0.0824, 0.0050, and 0.0818, respectively.

[17]We defined these contracts in the following way. It must be the case that $y - x < 16$ since they do not incentivize high effort. We also had the restriction $y - x \geq 12$, so agents do not have strong incentive to choose low. Finally, $y \in [12, 18]$ and $z \in (12, 24]$ and $z \geq y$, so that the agent is strictly better off than choosing low with the null contract and the principal never gives away more than half the revenue. Since $y$ is no smaller than twelve, the restriction $z \geq y$ ensures the contract is monotonic.

[18]Using a 1-sided Fisher's exact test yields p-values of 0.0679, 0.0704, and 0.0101 for rounds 3, 4, and 5, respectively.

Table 4: **Extra Surplus to Agents**

| | **All Rounds** | **Paid Rounds** | **Final 3 Rounds** |
|---|---|---|---|
| **Type (H) All Incentivizing Effort=12** | 15.13 | 11.07 | 11.70 |
| **Type (C) All Incentivizing Effort=12** | 9.47 | 6.76 | 5.99 |
| **Type (H) Non-monotonic Incentivizing Effort=12** | 6.21 | 4.0 | 4.0 |
| **Type (C) Non-monotonic Incentivizing Effort=12** | 4.99 | 4.59 | 4.18 |

### *6.2. Agent Behavior*

To further understand the difference in contracts offered between the types, it is instructive to look at the behavior of the human agents in Type (H). In all paid rounds, agent subjects chose the option with higher expected value in 66% of cases, a significant amount of the time (Two-sided Binomial Test, p=0.0006), in line with the results of Keser and Willinger (2000) who found agents acted in such a way roughly 70% of the time. Of the 43 instances of agents choosing the lower expected value action, five of the cases (11.6%) were choosing *Effort=0* when expected value was higher for *Effort=12*. Three of those five instances consisted of theoretically incentivizing non-monotonic contracts.[19] Even though one of those contracts (0,16,12) guaranteed the agent would do no worse selecting higher effort, an agent still chose low effort the contract. Because non-monotonic contracts decrease the payment to the agent as the revenue to the principal increases, agents may view these contracts as "unfair", even if they split the ex-ante surplus evenly. For example with (0,16,12), when the HIGH outcome occurs compared to the MEDIUM outcome, the principal earns 20 ECUs more while the agent earns 4 ECUs less. Of the contracts where agents chose *Effort=12* even when it had lower expected value, 14 (36.8%) occurred in response to non-incentivizing "fair" contract while 7 (18.4%) were in response to overly generous non-incentivizing contracts (those that fail meet our criterion of "fair" because they reward the agent so much). Another 13 (34.2%), 7 non-monotonic and 6 monotonic,[20] either covered or nearly covered the agent's cost of effort for the MEDIUM outcome (and often the HIGH outcome as well).

[19] These three non-monotonic contracts were (0,16,0),(0,16,8) and (0,16,12).

[20] The non-monotonic contracts were (0,14,7);(0,12,8);(2,10,8);(0,12,10);(3,12,8);(1,10,5) and (0,12,8). The monotonic contracts were (0,10,14);(6,12,12);(0,10,14);(0,12,12);(0,10,15) and (0,10,10)

Agents who responded favorably to these contracts may be primarily concerned with total surplus, and some of these contracts fully compensated the agent for the cost of effort, providing the opportunity for a Pareto improvement compared to the use of the null contract. In three cases, agents responded positively to very unfavorable contracts.[21] These agent likely either strongly preferred to maximize total surplus or had limited cognitive abilities. Finally, in one case an agent responded favorably to the contract (0,3,24), possibly because the agent viewed it as fair since it "shares" the surplus when the lucky outcome occurred and provided some payment for the MEDIUM outcome.

The reaction of human agents to contracts that did not provide higher expected value for *Effort=12* was the main driver behind the difference in earnings between principals in Type (H) and Type (C). Principals in Type (H) earned an average of 86.64 ECUs compared with 81.68 ECUs for principals in Type (C), though the difference was not statistically significant (Two-sided Mann-Whitney U, p=0.2187). If agents had behaved as risk-neutral, ex-ante profit maximizers, principals in Type (H) would have earned over 10 ECUs less than principals in Type (C), instead of the roughly 5 ECUs more we observed.

### *6.3. Increased value to principals from contracting*

Principals in both types had the option to choose the null contract: (0,0,0). In Type (H), 17.6% of all paid contracts were the null contract, rising to 20% in the final three rounds. In Type (C) 11.5% of all paid contracts were the null contract, rising to 14.2% in the final three rounds. The bigger difference between types occurred in the frequency of contracts that offered higher expected value to the principal than the null contract in theory, assuming the agent took the incentivized action. Only four percent of all contracts in Type (H) were theoretically better in expectation for the principal than the null contract, for both all paid rounds and only the last three rounds.[22] In Type (C) however, 22.5% of contracts (in all paid rounds) and 27.5% of contracts (in the final three rounds) were better than the null contract. Looking at the trend across all eight periods, the number of incentivizing contracts that offer at least as much profit as the null increased monotonically over time in Type (C). (Two-sided Mann-Kendall Test, p=0.0142)

There are several potential explanations for this disparity. One reason is the consistency of behavior by the computer agent: because the computer agent only cared about maximizing its expected payoff, principals were certain of the agent's behavior for a contract incentivizing *Effort=12*. On the other hand in Type (H), three out of five non-monotonic contracts that were better than the null contract for principals and should have incentivized higher effort from the agent did not actually produce higher effort from the human agent.

[21] There were two instances of agents rewarding the null contract and one where they rewarded (1,1,1) with *Effort=12*.

[22] One subject continuously offered theoretically profitable contracts, all of which were non-monotonic.

The other likely reason for the difference is the relative lack of punishment by human agents for constructing a contract where selecting *Effort=0* for the agent still had slightly higher expected value than *Effort=12* (where Eq. 2 does not hold, but the values are close) such as with "fair" contracts and those that roughly compensated agents for the cost of effort. Because agents frequently rewarded principals with these contracts, principals may have continued to offer such contracts instead of finding the contracts that would give higher expected value to agents for choosing *Effort=12*. For example, the proportion of "fair" contracts increased from 19.2% in all rounds to 22.7% in the last three rounds, suggesting agent behavior encouraged more of these types of contracts. Because computer agents only considered the expected value of each action, they never rewarded contracts that were close to incentivizing higher effort. The principals in Type (C) seemed to respond in two ways: they determined which profitable contracts fully incentivized the computer [going from 22.5% in all paid rounds to 27.5% in the final three rounds for incentivizing contracts with greater value than the null contract], or they stopped attempting to incentivize higher effort [going from 11.5% null contracts in all paid rounds to 14.2% in the final three rounds]. In both types, many principals seemed to be responding rationally to the behavior of the agents with whom they were paired.

### *6.4. Efficiency*

Only the agent affects the efficiency in our environment by increasing the expected surplus through the high effort action, while the principal simply makes transfer payments. Given the decision-rule of the computer agent in the Type (C), the amount of efficient choices is the same as the amount of contracts that theoretically incentivize the efficient choice, which stood at 38.5% over the paid rounds. However, with the human treatment, principals only offered theoretically efficient contracts 13.6% of the time. The proportion of theoretically efficient contracts in Type (C) exceeded that of Type (H) in all paid rounds, with significance in all but the first paid round.[23] Although human agents only had an incentive to choose the efficient decision 13.6% of the time, they selected it 40% of the time in the paid rounds.

Comparing the rate of efficiency (in other words comparing the percentages of high effort between the treatments) using a Fisher's exact test yields no significance in any round, with the largest difference in the final round (p-value=0.1992 using a 2-sided test in last round). Thus, the theoretically suboptimal behavior of agents, whether from a concern for fairness, a preference for maximizing total surplus, or bounded rationality, caused both treatments to have roughly the same level of efficiency. Although suboptimal behavior of the agents basically eliminates the amount of inefficiency between treatments, agents chose the inefficient action a majority of the time in all rounds except one in both treatments (Round 4 in both Type (C) and Type (H)).

[23] Using a 2-sided Fisher's exact test yields p-values of 0.0605, 0.0798, 0.0029, and 0.0298 for rounds 2, 3, 4, and 5, respectively.

## 7. Conclusion

More than thirty percent of contracts in the treatment with the computer agents exhibited non-monotonicity; thus, a large portion of the population understands these unusual contracts may be optimal in particular situations. Furthermore, slightly less than one is six contracts were non-monotonic with the human agents, indicating principals recognized a difference in using non-monotonic contracts when paired with another person as compared to a computer.

In every round, principals offered fewer non-monotonic contracts to humans than the computer agents. Although some of these non-monotonic contracts failed to create the incentive to choose high effort, these numbers indicate that more principals used the correct qualitative structure of the theoretically optimal contract when matched with computer agents. The survey principals completed at the end of the experiment, asking how they would decide if interacting with the agent from the other treatment, indicates that some principals with human agents believed that humans would fail to act as risk-neutral profit-maximizers. Roughly fifty-seven percent of principals stated in our survey that they would offer different contracts to the two different types of agents.

Survey responses suggest that several of the principals had concerns regarding the rationality of the human agents, a few seemed worried about fairness, and none seemed concerned with risk attitudes (likely because our design accounts for such factors). Unlike other causes of poor decisions by the players, a lack of understanding of the game, or the "rationality" of a player, can be corrected with further instruction. The following quotes demonstrate the concern of some of the principals regarding the rationality of the human agents:[24]

> "People aren't as rational [as computers]; some will be swayed by a slightly higher round number without calculating the exact probabilistic payoffs of each scenario."

> "I changed it [the contract] because I know the computer program will calculate which decision makes the most money on average, but a person may not or might make errors."

The principals above had reason to worry about the rationality of human agents as many failed to respond optimally, even in one case with a contract that fully accounts for risk-aversion, (0,16,12). Agents may have responded this way due to the inequity in the realized payments with such contracts. Principals, according to the data, responded by offering fewer non-monotonic contracts in later periods.

[24]These quotes are responses to our survey in Type (C) asking how principals would behave differently if interacting with a human in the role of agent.

As the experiment progressed, principals created more non-monotonic contracts with computer agents and fewer with humans ones. Given the decisions of the human agents, offering fewer non-monotonic contracts was not necessarily suboptimal for the principal. Below is a quote expressing the frustration of one of the principals that contracted with human agents:[25]

> "I would make different payments to the computer program because it understands how to maximize its profit unlike the morons playing today unless they based their answers on how much more money I would make as player 1 [the principal]."

The quote also demonstrates that some principals seem aware of inequity as possible issue. A few principals from Type (C) even discussed their own preferences for fairness.[26]

> "I would pay slightly more for each higher payment, that way both player 2 [the agent] and myself end up earning more."
>
> "I would like to be more fair with a person."

Because the contracts failed to shift towards theoretically profitable contracts (that paid at least as well as the null) as the rounds progressed in Type (H), in contrast to Type (C), it does not appear more periods would lead players towards contracts derived from traditional economic theory in Type (H). Our experiment shows how agents responded, often sub-optimally, but not why they often selected the action that earned them less money. Whether the human agents made poor decisions due to a lack of understanding, a desire to reward generous principals, or other reasons is outside the scope of this experiment. However, their actions are somewhat consistent with a concern for fairness (ex-post) and efficiency. Future work could use our methodology and design a similar experiment to ours with a larger focus on the agents, such as by having the computer act as a principal that randomly creates contracts for each agent. One could also reduce the concerns on rationality of the agent by including a communication treatment where the principal explains why a given contract was offered via text. Presumably, agents may behave differently when they understand the reasoning behind the structure of the contract, whether one is constructed with fairness in mind or because it has an unusual non-monotonic structure. Our computer treatment is similar to a communication treatment where human agents text the principals regarding their own preferences for contracts, except the computer treatment obviously had a homogeneous preference and an inflexible decision rule while the human agents may have

[25]This quote is a response to our survey in Type (H) asking how principals would behave differently if interacting with a computer in the role of agent.

[26]Once again, these quotes are responses to our survey in Type (C) asking how principals would behave differently if interacting with a human in the role of agent.

heterogeneous preferences over the contract space and flexibility when deciding.[27] A treatment where the agent communicates would allow us to better understand the motivation behind their decisions.

The suboptimal responses of agents, however, increased efficiency when they selected *Effort=12* even though *Effort=0* provided a larger payoff. This behavior caused the overall rate of efficiency in Type (H) to roughly equal that of Type (C). Furthermore, the principals in the experiment actually earned more with human agents than with computer agents, though not a statistically significant difference. Therefore, agent behavior could mitigate the loss of surplus in scenarios with non-monotonic contracts because human agents either respond with other-regarding preferences in mind, or they lack the comprehension skills to choose optimally. Since more than sixty percent of contracts were not non-monotonic with computer agents, many subjects seem not to comprehend the optimality of non-monotonic contracts. Furthermore, human agents responded negatively to non-monotonic contracts in a few cases.

Our work shows that non-monotonic contracts are indeed unintuitive to many principals as the majority of contracts in each treatment fail to have a non-monotonic structure. However, since roughly half as many principals offered human agents non-monotonic contracts compared to computer agents, there seems to be rationality concerns or other-regarding preferences, such as fairness on either the part of the principal or agent, affecting the decisions of the principals in this treatment. Because agents often responded favorably to theoretically suboptimal contracts that roughly compensated for cost of effort or could be perceived as "fair", efficiency was almost the same between treatments. Given our current results, we find no evidence to recommend the wide adoption of non-monotonic contracts, though more work needs to be completed, especially research focusing more on the motivation and choice of the agent. In his work on contracts and limited liability, Innes (1990) included a constraint that payments to agents must increase with profit. This constraint is often included in principal-agent problems, because the principal and agent sometimes have an incentive to manipulate the profit or output of the firm in order to decrease or increase the wage to the agent. For example, a salesperson may avoid making additional sales to prevent profit from increasing if given a non-monotonic contract. Our work shows that this constraint may seem reasonable, even when such profit manipulation is not feasible, as principals either do not comprehend such contracts, worry about agent response, believe efficiency concerns motivate agents, or prefer equitable outcomes, which would prevent the use of non-monotonic contracts.

**Acknowledgements**: We thank Collin Weigel for helping us with SoPHIE software, Charles Noussair for helping with the laboratory, and Stan Reynolds for his support and guidance. We would also like to thank the Graduate and Professional Student Council at the University of Arizona for funding this project. Finally, we would like to thank two anonymous referees for their helpful suggestions that improved this paper.

[27] Some may care more about fairness while others care more about risk or their own payoff.

*The following instructions were given to subjects in the sessions with a human playing the role of the agent*

# Instructions

Table 1: Probabilities

| Outcomes / Actions | ***LOW*** **Payment = 12** | ***MEDIUM*** **Payment = 36** | ***HIGH*** **Payment = 48** |
|---|---|---|---|
| **A Cost = 0** | 3/4 | 0 | 1/4 |
| **B Cost = 12** | 0 | 3/4 | 1/4 |

GAME STRUCTURE

1. Player 1 offers Player 2 a payment for each possible outcome, LOW, MEDIUM, and HIGH: any number between 0 and 12 Experimental Units (EUs) for the LOW outcome, between 0 and 36 EUs for the MEDIUM outcome, and between 0 and 48 EUs for the HIGH outcome. Player 2 receives an endowment of 20 EUs.
2. Player 2 observes the offers given for each outcome (LOW, MEDIUM, and HIGH) from Player 1 and chooses either "Action A" or "Action B." Player 2 pays nothing to choose "Action A" and pays 12 EUs from the endowment of 20 EUs to choose "Action B." The decision of Player 2 affects the probability of each outcome. The probability of an outcome given an action can be found in Table 1 above by looking at the intersection of an outcome and the corresponding action. For example, the MEDIUM outcome occurs three out of four times if Player 2 chooses "Action B".
3. An outcome is randomly generated with the probabilities in the Table 1 according to the action Player 2 selected (see Step 2 above). Player 1 earns 48 EUs for the HIGH outcome, 36 EUs for the MEDIUM outcome, and 12 EUs for the LOW outcome (payments **for Player 1** listed in Table 1 above in the top row below the outcomes). From these earnings, Player 1 pays Player 2 the payment offered for the given outcome (see Step 1). Player 2 receives the payment from Player 1 for the given outcome in addition to the endowment of 20 EUs minus the cost of the selected action (nothing for "Action A" and 12 EUs for "Action B").

The game will be played eight times, three for practice (unpaid) and five paid. In each round, Player 1 and Player 2 remain in the same role but are randomly rematched with another Player 2 and Player 1 respectively. Player identities remain anonymous throughout. At the end of the experiment, each participant receives $1 for every 10 EUs earned in addition to the $5 show-up fee.

*The following instructions were given to subjects in the sessions with a computer playing the role of the agent.*

# Instructions

Table 1: Probabilities

| Outcomes / Actions | ***LOW*** **Payment = 12** | ***MEDIUM*** **Payment = 36** | ***HIGH*** **Payment = 48** |
|---|---|---|---|
| **A Cost = 0** | 3/4 | 0 | 1/4 |
| **B Cost = 12** | 0 | 3/4 | 1/4 |

GAME STRUCTURE

1. You, in the role of Player 1, offer a computer program, in the role of Player 2, a payment for each possible outcome, LOW, MEDIUM, and HIGH: any number between 0 and 12 Experimental Units (EUs) for the LOW outcome, between 0 and 36 EUs for the MEDIUM outcome, and between 0 and 48 EUs for the HIGH outcome. Player 2 receives an endowment of 20 EUs.
2. Player 2, the computer program, learns the offers given for each outcome (LOW, MEDIUM, and HIGH) from Player 1 and chooses either "Action A" or "Action B." Player 2 pays nothing to choose "Action A" and pays 12 EUs from the endowment of 20 EUs to choose "Action B." Player 2, the computer program, chooses the action that makes it the most money on average. Thus, the decision of Player 2, the computer program, is not random. The decision of Player 2 affects the probability of each outcome. The probability of an outcome given an action can be found in Table 1 above by looking at the intersection of an outcome and the corresponding action. For example, the MEDIUM outcome occurs three out of four times if Player 2 chooses "Action B".
3. An outcome is randomly generated with the probabilities in the Table 1 according to the action Player 2, the computer program, selected (see Step 2 above). Player 1 earns 48 EUs for the HIGH outcome, 36 EUs for the MEDIUM outcome, and 12 EUs for the LOW outcome (payments **for Player 1** listed in Table 1 above in the top row below the outcomes). From these earnings, Player 1 pays Player 2 the payment offered for the given outcome (see Step 1). Player 2, the computer program, receives the payment from Player 1 for the given outcome in addition to the endowment of 20 EUs minus the cost of the selected action (nothing for "Action A" and 12 EUs for "Action B").

The game will be played eight times, three for practice (unpaid) and five paid. At the end of the experiment, each participant receives $1 for every 10 EUs earned in addition to the $5 show-up fee.

[1] Anderhub, Vital, Simon Gächter, and Manfred Königstein. “Efficient contracting and fair play in a simple principal-agent experiment.” Experimental Economics 5.1 (2002): 5-27.

[2] Bayer, Ralph C., and Ludovic Renou. ”Logical omniscience at the laboratory.” Journal of Behavioral and Experimental Economics 64 (2016): 41-49.

[3] Berg, Joyce E., Lane A. Daley, John W. Dickhaut, and John O’Brien. “Moral hazard and risk sharing: experimental evidence.” research in Experimental Economics 5, no. 1992 (1992): 1-34.

[4] Brosig, Jeannette, Christian Lukas, and Thomas Riechmann. “The monotonicity puzzle: an experimental investigation of incentive structures.” BuR-Business Research 3.1 (2010): 8-35.

[5] Epstein, Seth. “Testing principal-agent theory.” research in Experimental Economics 5 (1992): 35-60.

[6] Fehr, Ernst, Alexander Klein, and Klaus M. Schmidt. “Fairness and contract design.” Econometrica 75.1 (2007): 121-154.

[7] Fehr, Ernst, and Klaus M. Schmidt. ”A theory of fairness, competition, and cooperation.” The quarterly journal of economics 114.3 (1999): 817-868.

[8] Frock, Roger. Changing How the World Does Business: Fedex’s Incredible Journey to Success-the Inside Story: Easyread Super Large 18pt Edition. ReadHowYouWant. com, 2009.

[9] Grossman, Sanford J., and Oliver D. Hart. “An analysis of the principal-agent problem.” Econometrica: Journal of the Econometric Society (1983): 7-45.

[10] Hendriks, Achim: SoPHIE - Software Platform for Human Interaction Experiments. University of Osnabrueck, Working Paper, 2012

[11] Hoppe, Eva I., and Patrick W. Schmitz. “Contracting under incomplete information and social preferences: an experimental study.” The Review of Economic Studies (2013): rdt010.

[12] Hoppe, Eva I., and Patrick W. Schmitz. “Do sellers offer menus of contracts to separate buyer types? An experimental test of adverse selection theory.” Games and Economic Behavior 89 (2015): 17-33.

[13] Hvide, Hans K. “Tournament rewards and risk taking.” Journal of Labor Economics 20.4 (2002): 877-898.

[14] Innes, Robert D. “Limited liability and incentive contracting with ex-ante action choices.” Journal of economic theory 52.1 (1990): 45-67.

[15] Johnson, Eric J., Colin Camerer, Sankar Sen and Talia Rymon. "Detecting failures of backward induction: Monitoring information search in sequential bargaining." Journal of Economic Theory 104.1 (2002): 16-47.

[16] Keser, Claudia, and Marc Willinger. "Principals' principles when agents' actions are hidden." International Journal of Industrial Organization 18.1 (2000): 163-185.

[17] Keser, Claudia, and Marc Willinger. "Theories of behavior in principal-agent relationships with hidden action." European Economic Review 51.6 (2007): 1514-1533.

[18] Lukas, Christian. "Get more for less? Experimental evidence on repeated decision making under non-monotone incentives." Zeitschrift für Betriebswirtschaft 77.4 (2007): 351-379.

[19] McKinney, C. Nicholas, and John B. Van Huyck. "Estimating bounded rationality and pricing performance uncertainty." Journal of Economic Behavior & Organization 62.4 (2007): 625-639.

[20] Reiss, J. Philipp, and Irenaeus Wolff. "Incentive effects of funding contracts: an experiment." Experimental Economics 17.4 (2014): 586-614.