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AN EXPERIMENTAL EVALUATION OF THE STRATEGIC USE OF MANAGERIAL INCENTIVE

CONTRACTS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree of Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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*****

The Ohio State University
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ABSTRACT

Much accounting research has focused on cost allocation strategies. New cost-allocation systems, such as activity-based costing, have been developed and explored. Even with these new systems, some firms continue to employ less precise allocation methods that over or under-allocate costs. This paper attempts to demonstrate an explanation of why firms might wish to over or under-allocate costs by experimentally examining a duopoly market.

The goal of the paper is to demonstrate that there are conditions that may exist where the owners of the firm are made better off by over or under-allocating costs. The owners offer a contract to their manager that is a weighted combination of revenues and costs. The owner selects the contract by deciding what percentage of production costs to assign to the manager. Once the owners of both firms have selected their cost allocation strategy, both contracts are revealed. The managers then select how much output to produce. The market then purchases all production at the market clearing price.

The experiment provides mixed results. Under one parameter set, the owners are better off by offering the weighted-contract to their managers. In the other parameter set, the owners are better off by offering the quantity-contract
(strict profit maximization) to their managers. The results are consistent with the model based on the contracts offered by the owners. Evidence does exist to support the claim that there are market conditions under which the weighted-contract is superior to the standard profit-maximizing contract.
Dedicated to Mom and Dad

Thanks for all of your help.
ACKNOWLEDGMENTS

I wish to thank Anil Arya, Connie Butler, John Fellingham, Christine Harrington, Steve Schwartz, Eric Spires, Dave Wallin, and Rick Young for their help and comments. I would also like to acknowledge the participants of the accounting workshops at the Universities of Marshall, Penn State - Harrisburg, and The Ohio State University for their comments on earlier drafts of the dissertation.

The Ohio State University Graduate School Alumni Research Award and the Department of Accounting and MIS were generous with grants that made it possible to fund the experiment.

I also wish to thank all of my fellow doctoral students. Their help and friendship have helped to make the completion of this paper possible. Special thanks to Steve Schwartz and Christine Harrington.
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CHAPTER 1

INTRODUCTION

Methods to improve cost allocations have been the subject of accounting research (Banker and Hughes [1994] and Merchant and Shields [1993]). New cost systems, such as activity-based costing, have been explored in an attempt to help firms improve decision making. Even with these new costs systems, firms continue to employ cost-allocation policies that under or over-allocate costs back to the manager (Merchant and Shields [1993] and Govindarajan and Anthony [1983]). This paper attempts to demonstrate why firms might intentionally under or over-allocate costs. In the experiment, the production manager of the firm makes all output decisions. The owner of the firm offers a contract to the manager that provides incentives for the manager to select output levels which will maximize the owner's profits.

It can be shown (Fershtman and Judd [1987] and Sklivas [1987]) that compensating managers based on a weighted combination of revenues and costs may, in theory, result in higher firm profit than compensating managers solely on profit. For this to occur, it is necessary for the contracts to be offered to the managers before output decisions are made. Such a contract may allow an
owner to influence the output levels selected by the manager by changing the manager’s incentives. A contract which provides a manager with incentives to increase revenues (possibly at the expense of profits) will create incentives for aggressive (higher) output decisions by that manager. Due to the interaction of the firms in a duopoly market, this aggressive output may influence the rival manager to decrease their output levels, leading to higher profits for the aggressive firm.

The owner may use the contract offered to the manager as a form of commitment to an aggressive output policy. This allows the owner the opportunity to implement an incentive scheme that, ceteris paribus, promotes more aggressive behavior (higher output levels) by their manager while simultaneously promoting less aggressive behavior (lower output levels) by the rival firm’s manager. Therefore, one firm may increase market share and profits at the rival firm’s expense. When this opportunity is available to both owners, an equilibrium may exist wherein both owners provide incentives to their managers to make aggressive output decisions. The managers will respond by selecting output levels that are higher than the output levels under Cournot competition, resulting in lower profits for both firms. As is the case in Cournot competition, the owners may prefer to collude in order to share the monopoly profits, although this outcome is off the equilibrium path. By sharing the monopoly profits, the firms are able to maximize their combined welfare. In this setting, contracting between the owner and the manager may be used to commit the firm to any competitive
strategy desired by the owner. This form of commitment may increase the ability of the owners to cooperate and receive profits higher than those achieved at the Cournot equilibrium.

In the experiment, the owners privately select a contract for their manager by selecting a weighted combination of revenues and costs. The owner determines what percentage of production costs to assign to the manager. The owner may hold the manager responsible for "true" costs, that is 100% of the production costs. Alternatively, the owner may "under-allocate" costs by assigning less than 100% of the production costs to the manager or the owner may "over-allocate" by assigning more than 100% of the production costs to the manager. This allocation may be compared to a firm absorbing some divisional costs at the corporate level (under-allocation) or assigning corporate costs to the division (over-allocation). Once selected, both contracts become public knowledge. Each manager responds by selecting an output level for their firm that maximizes their personal compensation. The subjects are presented with a series of two prisoner’s-dilemma-like games,\(^1\) wherein, the owners have the opportunity to cooperate together by selecting cost-allocation strategies that allow the firms to share in increased profits, including the possibility of sharing the monopoly level profits. Each owner has incentives to defect by offering their manager a contract containing aggressive incentives. There is a unique Nash

\(^1\) The games are similar to Prisoner Dilemma games since each participant has the option to cooperate in an attempt to share higher profits or to defect in an attempt to increase market share and profits at their competitor's expense. Unlike a Prisoner's Dilemma game, this game allows selection of choices from a continuous spectrum, thus participants are faced with a multitude of outcomes instead of just four.
equilibrium solution to the owner's game. The managers have the opportunity to cooperate together by restricting their combined output level to increase their compensation. Each manager has incentives to defect by selecting a higher output level to increase their compensation at the rival firm and rival manager's expense. The manager's game also has a unique Nash equilibrium solution.

This paper will attempt to demonstrate that strict-profit-maximization (quantity-contract) is not always the best contract available to the firm. By over or under-allocating costs (weighted-contract), a firm may be able to influence employee actions and implement firm strategies that increase firm profits. The firm may also be able to favorably influence the actions of rival firms.
2.1 Economic Model

Sklivas [1987] examines a one-period, two-stage Cournot duopoly game. Each firm consists of an owner and a manager. In the first stage, the owners simultaneously write contracts which are then publicly announced. These contracts determine how the managers will be compensated. In the second stage, the managers select output levels for their firm. The market purchases all output from both firms at the market clearing price, the managers' compensation is calculated, and the owners earn the residual profits.

The contract written by the owners is a linear combination of profits and revenues.

\[ \lambda_i \Pi_i(x_1, x_2) + (1 - \lambda_i)R_i(x_1, x_2) \quad i \in \{1, 2\} \quad (1) \]

Where:  
$\Pi_i$ is the profit for firm $i$  
$R_i$ is the revenue for firm $i$  
$x_i$ is the output level for firm $i$  
$\lambda_i$ is the relative weighting between profit and revenue for firm $i$.  

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The above contract may be re-stated as a linear combination of revenues minus allocated costs.

\[ R_i(x_1, x_2) - \lambda_i C(x_i) \quad i \in \{1, 2\} \quad (2) \]

Where: \( C \) is the constant marginal cost of producing one unit of output.

This contract is an extension of the profit-maximization contract. If an owner selects \( \lambda_i = 1 \), then the contract offered is the profit-maximization contract. The owners have the opportunity to offer the profit-maximizing contract or they can offer any variation that is preferred by the owners.

The firms are assumed to be producing a homogeneous product with identical marginal costs. The market is assumed to purchase all output from both firms and the market clearing price \( P \) is determined by an inverse-demand function, \( P = a - bX \), where \( a > 1 \) and \( X = x_1 + x_2 \).

The first step is to solve the managers' game by finding their best-response function by substituting for \( P \) and solving the first-order conditions.

\[ x_i = \frac{(a - \lambda_i - bx_j)}{(2b)} \quad i, j \in \{1, 2\}, \ i \neq j \quad (3) \]
Thus each manager will select their optimal output level based upon the weight ($\lambda_i$) in their contract and the output level ($x_j$) of the rival firm. The optimal output level is decreasing in $\lambda_i$, thus as the owner increases the weight placed on costs the manager responds by selecting a lower output level for the firm. By substituting for $x_j$, the Nash equilibrium output levels as a function of $\lambda_i$ and $\lambda_j$ are obtained.

$$x_i = (a - 2\lambda_i + \lambda_j) / (3b) \quad i, j \in \{1, 2\}, i \neq j$$ (4)

In equilibrium, the output level of the firm depends on the weight selected for both contracts. An owner is able to affect the output levels of both firms based upon the selection of $\lambda_i$. The lower (higher) the value selected by an owner, the higher (lower) their firm’s production and the lower (higher) the rival firm’s production, ceteris paribus.

Now the owners’ game can be solved. The owners are assumed to be profit-maximizers, thus the owners’ objective function is to maximize firm profit.²

$$\text{Max}_{(i,j)} Px_i - Cx_i \quad i, j \in \{1, 2\}, i \neq j$$ (5)

² Sklivas does not consider the effects of manager compensation on firm profit.
By substituting for $P$ and $x_i$, the owners' best response functions can be calculated and the Nash equilibrium found. The best response functions are as follows:

$$\lambda_i = \frac{6 - a - \lambda_j}{4} \quad i, j \in \{1, 2\}, i \neq j \quad (6)$$

The owner's selection of $\lambda_i$ is dependent on the rival firms selection of $\lambda_j$. The higher the value for $\lambda_j$ selected by the rival owner, the lower the value selected for $\lambda_i$. By substituting for $\lambda_j$, the Nash equilibrium level of $\lambda_i$ may be obtained:

$$\lambda_i = \frac{6 - a}{5} \quad i \in \{1, 2\} \quad (7)$$

Sklivas concludes that, in this setting, firms continue to act as profit-maximizers. However, they now act as if their costs were $\lambda C$ instead of $C$. If $\lambda C < (>) C$ for both firms, then the managers will select higher (lower) output levels and the owners will receive lower (higher) profits than under Cournot competition ($\lambda_i = \lambda_j = 1$). There is an incentive for an individual owner to select a value for $\lambda_i < 1$. If one owner selects a value for $\lambda_i < 1$ while the other owner selects $\lambda_j \geq 1$, the first owner will increase market share and profits at the rival firm's expense. When both owners follow this strategy, the result is increased output and lower profits for both firms.
Fershtman and Judd [1987], hereafter referred to as FJ, examine the same setting with similar results. FJ observe that there is no reason in the current setting for owners to abandon a quantity-contract in favor of the contract based upon the weighted combination of revenue and cost, since the quantity-contract provides higher equilibrium owner profits than the weighted-contract. However, when uncertainty about the environment is introduced, the weighted contract may be superior to the standard quantity-contract. When uncertainty in the production costs exist, the weighted-contract is superior as it allows the manager to select the optimal output level given the realized cost. FJ conclude that owners may provide incentives other than strict profit-maximization to their managers in order to maximize owner profits. Incentives may be used as strategic tools. External competition is important in determining the optimal incentive structures. If these incentives may be designed in such a way that alters the rival manager's actions in a beneficial direction, then the incentive structure has value as a strategic tool.

2.2 ACCOUNTING IMPLICATIONS

Horngren [1970] states that cost allocation is "fundamentally a behavioral question" and makes the following observation (p. 333):

"Whether to include uncontrollable or indirect costs is a difficult question which ultimately should be resolved in terms of how the given alternatives influence management behavior in a particular organization. In one organization, allocation may be desirable because it induces the desired behavior." (emphasis in original text)
In this paper, the owner's choice of how much cost to allocate to the manager influences the manager's output decisions. This allows the owner to induce the desired behavior (output aggressiveness) from the manager.

Zimmerman [1979] supports Horngren and goes on to state that cost allocations when combined with incentive schemes that help motivate and control managers may improve the welfare of the owners. Zimmerman's analysis demonstrates that managerial behavior is inextricably linked with managerial incentives and cost allocations. In this paper, the owner is able to modify manager incentives by altering the cost allocation strategy. As long as the benefits (increased owner profit) outweigh the costs (bookkeeping costs and decision errors), rational individuals are expected to employ allocation techniques.

Goering [1996] examines the beliefs of the managers. Goering allows the managers to hold individual beliefs that are not based on Cournot conjectures. Managers are then classified by their beliefs or aggressiveness. Goering finds that owners must consider the management style of both their own manager and the rival manager before designing an incentive plan. An owner will select incentives for their manager that maximize the owner's profits based on the actions of the rival manager, reinforcing the idea that incentives may be used for strategic reasons. In Goering's model, owners select incentives based on both strategic reasons and management styles. Uncertainty about management styles may allow the weighted combination contract to outperform the quantity-contract.
Govindarajan and Anthony [1983], hereafter referred to as GA, examine how firms use costs. GA find that managers are often unable to apply the profit maximizing model. Managers rarely have the resources needed to discover all of the parameters necessary to solve the profit maximizing model. Also, since factors such as product quality and promotional strategies are not included in the profit maximizing model, it may not be the optimal decision strategy.

Merchant and Shields [1993], hereafter referred to as MS, find many situations where it not in the best interest of the firm to use the most accurate cost measurement (allocation) available. Accuracy in measuring costs is defined by MS to be comprised of two components, freedom from bias and precision. A measure that is free from bias is not skewed, upward or downward, from its "true" value. To be precise, a measure must contain no randomness or noise. MS argue that some firms intentionally introduce inaccurate measurement (bias) of costs to promote desirable responses (i.e. to modify behavior) from their employees.

MS state that firms may intentionally overstate costs when facing competitive pricing situations in order to protect the firm from excessively shaving prices. MS found examples of firms that benefit from this policy whether or not their employees are aware of the cost overstatement. Firms understate for two reasons: motivational purposes and to stimulate the consumption of in-house services.
MS also find that firms use less precise measures of cost measurement to focus employees attention on firm goals. These firms intentionally used relatively imprecise cost systems that sometimes overstate costs and at other times understate costs. The goal of these firms is to concentrate employee attention on continuous improvement and competitive advantage. As a result, the firms are able to focus their employees on the factors deemed to be critical for success.

MS conclude that using less accurate cost measurements may aid a firm to implement a predetermined strategy. It is important to note that the firms using the less accurate cost systems were using them to "implement, not develop, competitive strategies." (Merchant and Shields [1993] page 80) The use of less accurate cost measurements may help motivate employees to the desired action and aid the employees to implement desired firm strategies. Psychology, not just economics, should guide the development of cost measurement systems.
3.1 THE MODEL

The model used in this paper is an extension of the model used by Sklivas and FJ. The manager is hired by the firm to provide the expertise necessary for production to occur and makes all production decisions for the firm. The owner offers a binding contract to the manager by selecting a cost allocation strategy. This contract pays the manager a percentage ($\alpha$) of \{revenues minus allocated costs\}.

Sklivas [1987] did not consider manager compensation when solving the game. Fershtman and Judd [1987] assume that the managers are paid at the margin according to the contract that they were offered. In the experiment in this paper, the managers receive no salary, all compensation is generated by the "$\alpha$" percentage of the contract that they receive. Instead of treating $\alpha$ as a constant, $\alpha$ could be treated as a parameter that the owner solves to maximize profit. Changing $\alpha$, ceteris paribus, does not change the managers output decisions, it only changes how firm profits are shared between the owner and the manager.
(see Appendix A for an example). The value of 0.1 was selected for $\alpha$ in this paper for two reasons. First, this value provides a spread between the Nash, Cournot, and monopoly values of $\lambda$ that is large enough to allow for analysis of the experimental results. Second, it also provides the managers with compensation that is large enough to motivate the managers to work each period.

In this simple world, the "true" costs are equal to the accounting costs. The owner may offer a contract that allocates production costs ($C$) at their "true" level, over-allocates the production costs, or under-allocates the production costs to the manager. The owner selects the allocation strategy by selecting a weight ($\lambda$) to place on production costs ($\lambda C$). When $\lambda = 1$ production costs are allocated at their "true" level ($\lambda C = C$), when $\lambda > 1$ production costs are over-allocated ($\lambda C > C$), and when $\lambda < 1$ production costs are under-allocated ($\lambda C < C$) to the manager. The marginal production cost per unit ($C$) is constant for any output level within current capacity. The capacity is not binding.

After each manager receives their contract, they select an output level ($x_i$) for their firm that maximizes their compensation:$^3$

$$\max_{(x_i)} \alpha (P_{xi} - \lambda C_{xi}) \quad i \in \{1, 2\}$$

---

$^3$ The risk preferences of the managers and owners do not influence the outcome of the model.
Each manager solves their objective function by substituting for \( P (P = a - bX) \), solving the first-order conditions, and calculating their best-response function.

\[
x_i = \frac{(a - bX_j - \lambda_i C)}{2b} \quad i, j \in \{1, 2\}, i \neq j
\] (9)

This best-response function is dependent on the manager’s contract \( \lambda_i \) and the rival firm’s output level \( x_j \). The Nash equilibrium output levels, as a function of \( (\lambda_i, \lambda_j) \), may be obtained by substituting for \( x_j \) (see Appendix B for solution details).

\[
x_i = \frac{a + C(\lambda_j - 2\lambda_i)}{3b} \quad i, j \in \{1, 2\}, i \neq j
\] (10)

An examination of the equilibrium output levels shows the effects of the allocation strategy. When both owners select \( \lambda = 1 \), the output levels are the same as if there were no managers and the owners acted as the managers (Cournot competition). As an owner selects a lower (higher) value for \( \lambda \), then their manager increases (decreases) output while the rival manager decreases (increases) output, ceteris paribus. Figure one demonstrates the equilibrium output levels \( (x_i, x_j) \) as a function of the contracts offered \( (\lambda_i, \lambda_j) \).

\[^4\] \( \frac{\partial x}{\partial \lambda_i} = \frac{-2C}{3b}, \frac{\partial x}{\partial \lambda_j} = \frac{C}{3b}. \)
Figure 1: Graph of $x_i$ and $x_j$ as a function of $\lambda_i$

Holding $\lambda_j = 1$

Using parameter set one: $P = 80 - x_i - x_j$

$C = 20$

As shown in figure one, when the owner of firm $i$ increases (decreases) the weight ($\lambda_i$) placed on cost, ceteris paribus, the manager of firm $i$ decreases (increases) his output level while the manager of firm $j$ increases (decreases) his output level. For every two unit decrease (increase) in output by firm $i$, firm $j$ increases (decreases) output by one unit.
Each owner wants to select the value for $\lambda$ that will maximize his profits which is based upon his objective function. The owner receives the residual profits of the firm, which are the revenues minus the production costs minus manager's compensation.

$$\text{Max}_{(i,j)} P x_i - C x_i - \alpha(P x_i - \lambda_i C x_i) \quad i \in \{1, 2\} \quad (11)$$

The owners' objective function is solved by substituting for $P$, substituting the Nash equilibrium levels of $x_i$, and solving the first-order conditions.

$$\lambda_i = \frac{[4\alpha(a + C \lambda_j) - C \lambda_j - a + 6C]}{[4C(1 + 2\alpha)]} \quad i, j \in \{1, 2\}, i \neq j \quad (12)$$

By substituting for $\lambda_i$, the Nash equilibrium level of $\lambda_i$ may be obtained.

$$\lambda_i = \frac{[(12\alpha + 3)(6C - a + 4\alpha a)]}{[C(48\alpha^2 + 72\alpha + 15)]} \quad i \in \{1, 2\} \quad (13)$$

A unique Nash equilibrium exists for this game. This equilibrium is achieved when the owners select values for $\lambda$ based on (13) and the managers respond by selecting output levels based upon equation ten.
3.2 Owner Cooperation

The opportunity exists for the owners to increase profits above those earned at the Nash equilibrium. If the owners could collude together and write an enforceable contract on \( \lambda \), they could commit to a contract that would result in the total market production equaling the monopoly production.\(^5\) Each owner would offer the same \( \lambda \) and each manager would respond by offering one-half of the monopoly production.\(^6\) As a result each firm would earn one-half of the monopolist profits, increasing the residual profits received by each owner. This may be achieved if both owners offer the monopoly value of \( \lambda \) (\( \lambda_m \)).

\[
\lambda_m = \frac{[a(1 - \alpha) + 3C]}{[C(4 - \alpha)]} \quad (14)
\]

Assuming that each manager will select output levels based on equation ten (the Nash equilibrium output level), then each manager will select an output level equal to one-half the monopoly output (see Appendix C for solution details).

\[
x_m = \frac{[a(1 - \alpha) - C(1 - \alpha \lambda)]}{[4b(1 - \alpha)]} \quad (15)
\]

\(^5\) The owners could choose to contract on many different \( \lambda \) levels that would lead to profits higher than those achieved at the Nash equilibrium. For example, they could contract at \( \lambda = 1 \), the Cournot output level. However, it is the monopoly level which provides the highest joint profit. They could also contract on output quantity to achieve the same results.

\(^6\) The owners could agree to split the monopoly level production in non-equal amounts by offering different \( \lambda \)'s. Since the firms are identical, it is assumed that they share the output equally.
The choice of $\lambda_m$ by the owners is not on the equilibrium path. Each owner has incentives to defect (select a value for $\lambda_i$ less than $\lambda_m$) to increase market share and profits at the expense of the rival firm until they return to the Nash equilibrium. In this model, the owners cannot write an enforceable contract,\(^7\) so they can only share the monopoly profits if they both cooperate by offering contracts that provide the managers with incentives to share the monopoly output, such as $\lambda_m$. The use of the weighted-contract may make this cooperation easier to obtain as compared to the standard-quantity contract or the two player duopoly model where the owners select the output levels.

### 3.3 Manager Cooperation

The managers also have the opportunity to cooperate with each other in order to increase their compensation. Manager cooperation may benefit or harm the owners (see the numerical example in section 3.4 for details). The managers may be able to cooperate and produce the output level that maximizes their combined objective functions (see Appendix D for solution details). The combined objective functions of the managers are maximized when total output of both firms ($X$) is equal to the monopoly output of a firm with cost equal to $\lambda C$.

$$X = \frac{a - \lambda C}{2b} \quad (16)$$

---

\(^7\) An enforceable contract of this nature likely would violate anti-trust laws and would not be legally enforceable.
If the managers wish to share the compensation equally, they each would produce one-half of $X$ ($x_c$).

$$x_c = \frac{(a - \lambda c)}{4b} \quad (17)$$

As is the case with the owners, this cooperative outcome is not on the equilibrium path. Each manager has incentives to defect (select an output level $x_i$ greater than $x_c$) to increase their compensation at the expense of the rival manager, until they return to the equilibrium output levels. Cooperation between the managers may be more difficult to achieve when the managers are not offered identical contracts due to the increased difficulty of determining the optimal total output level and a method of dividing the optimal output.

### 3.4 Numerical Example

The following numerical example is based on the first parameter set used in the experiment.\(^8\)

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\(^8\) The numerical example for parameter set two is duplicated in Appendix E.
Owners' Objective Function

$$\text{Max}_{x_i} P x_i - C x_i - \alpha (P x_i - \lambda C x_i) \quad i \in \{1, 2\}$$

Owners' Equilibrium $\lambda$

$$\lambda_1 = \lambda_2 = [(12\alpha + 3)(6C - a + 4\alpha a)] / [C(48\alpha^2 + 72\alpha + 15)]$$

Managers' Objective Function

$$\text{Max}_{x_i} \alpha (P x_i - \lambda C x_i) \quad i \in \{1, 2\}$$

Managers' Equilibrium Output Level

$$x_i = \frac{a + C(\lambda_j - 2\lambda_i)}{3b} \quad i, j \in \{1, 2\}, i \neq j$$

Parameters

$$\alpha = .10 = \text{managers percentage of firm's weighted profits}$$
$$P = a - bX = 80 - X = \text{market clearing price}$$
$$X = x_1 + x_2 = \text{total market production}$$
$$C = 20 = \text{marginal cost to produce one unit}$$
$$\lambda = \text{the weight placed on C, selected by each owner}$$
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_1$</td>
<td>0.67</td>
<td>0.67</td>
<td>1.0</td>
<td>1.0</td>
<td>1.69</td>
<td>1.69</td>
</tr>
<tr>
<td>$x_i$</td>
<td>22.22</td>
<td>16.67</td>
<td>20</td>
<td>15</td>
<td>15.38</td>
<td>11.54</td>
</tr>
<tr>
<td>$P = a - bX$</td>
<td>35.56</td>
<td>46.67</td>
<td>40</td>
<td>50</td>
<td>49.23</td>
<td>56.92</td>
</tr>
<tr>
<td>Firm Profit</td>
<td>345.68</td>
<td>444.45</td>
<td>400</td>
<td>450</td>
<td>449.71</td>
<td>426.04</td>
</tr>
<tr>
<td>Manager Compensation</td>
<td>49.38</td>
<td>55.56</td>
<td>40</td>
<td>45</td>
<td>23.67</td>
<td>26.63</td>
</tr>
<tr>
<td>Owner Profit</td>
<td>296.30</td>
<td>388.89</td>
<td>360</td>
<td>405</td>
<td>426.04</td>
<td>399.41</td>
</tr>
</tbody>
</table>

Table 1: Solutions for the numerical example.

The table shows profit and compensation levels of the different strategy combinations. In the first column the owners and managers both implement the Nash equilibrium solution. The value for $\lambda$ is less than one, which promotes increased output levels by the managers when compared to the Cournot contract. These increased output levels lead to lower firm and owner profits but higher
manager compensation.\(^9\) In the second column, the managers cooperation increases firm profit, manager compensation, and owner profit.

Columns three and four show the results for the standard Cournot game (\(\lambda = 1\)). This equates to a two player game where there are no managers and the owners make all of the production decisions. When managers implement their Nash (Cournot) equilibrium output levels, the outcomes are identical to the two player game Nash (Cournot) equilibrium outcome. If managers cooperate then the two player monopoly profits are shared equally between the two firms. Manager cooperation again benefits the firm, the managers, and the owners.

In the fifth and sixth columns, the owners are cooperating in order to share the monopoly level profits.\(^{10}\) By over-allocating costs, the owners decrease output levels selected by the managers and allow the two firms to split the monopoly profits. This is the worst case scenario for the managers as they receive the lowest compensation. Managers may cooperate to improve their compensation, however, this cooperation now decreases firm and owner profits. This decrease is due to the total production being below the monopoly level.

---

\(^9\) The increased manager compensation could be eliminated by allowing \(\alpha\) to be a variable solved for by the owner. This would maintain expected manager compensation at the manager's opportunity wage.

\(^{10}\) The output levels are slightly higher in column five as compared to column four. This difference is due to treating \(\alpha\) as a constant. If \(\alpha\) was treated as a variable used to set expected manager compensation at the opportunity wage, then the output levels would be the same in columns four and five.
3.5 Motivation of the Weighted Contract

Related research has established that in a world without uncertainty the weighted contract does not outperform the strict profit maximizing (quantity) contract. One method to motivate the weighted contract would be to simply not allow output to be observable. This would eliminate the possibility of contracting on output. However, other more compelling reasons may exist.

A reason to explore the weighted-contract is the fact that it exists in practice (Fershtman [1985], Govindarajan and Anthony [1983], and Merchant and Shields [1993]). Many firms offer contracts to their managers that are based on profits, whether at the divisional level, corporate level, or both. Firms also use a variety of cost allocations schemes which affect how profit is measured.

Another reason is the flexibility of the weighted-contract. The owner may offer a weighted-contract that increases or decreases the aggressiveness of the manager. Once both contracts are revealed, the manager under the weighted-contract may select the best output level based on both their contract and their rival's contract. This may allow the manager to increase his compensation and his owner's profits by exploiting the rival manager's contract. The following table (based on parameter set two) demonstrates that if both firms are currently owner-only firms, one owner may exploit the other by hiring a manager and offering that manager a weighted-contract.
Both firms owner-only & Firm one hires manager & 
Firm 1 & Firm 2 & Firm 1 & Firm 2 
Effective or offered \( \lambda \) & 1.0 & 1.0 & 0.5 & 1.0 
\( x \) & 20 & 20 & 30 & 15 
Firm Profit & 800 & 800 & 1050 & 525 
Manager Compensation & 0 & 0 & 165 & 0 
Owner Profit & 800 & 800 & 885 & 525 

Table 2: Demonstration of the benefits of hiring a manager and offering the weighted-contract.

Thus an owner may prefer to hire a manager and offer the weighted-contract to the manager instead of remaining an owner-only firm.

Fershtman and Judd (1987) demonstrate that when uncertainty is introduced in the production costs, the weighted-contract does outperform the quantity-contract. When uncertainty in demand exists, the quantity-contract outperforms the weighted contract. Govindarajan and Anthony (1983) state that management often does not use profit-maximizing as they are unable to determine all of the variables necessary to solve the profit-maximizing problem. The inability to determine the costs with certainty might lead to the use of the weighted contract.
The original models are one-period models. The repeated play nature of the experiment may allow the subjects the opportunity to reach a level of cooperation that produces higher profits. It may be possible that the use of the weighted contract makes this cooperation easier to obtain. If this is the case, then the weighted contract may prove superior to the strict profit-maximizing contract form the owners' perspective. In the model, the weighted-contract leads to higher output levels that closer to production under pure competition. This is a benefit to society as a whole.
CHAPTER 4

EXPERIMENT DEVELOPMENT

4.1 OVERVIEW OF EXPERIMENT

The experiment is a 2 x 2, full-factorial design. The first treatment is between the two-player (owner only) game and the four-player (manager and owner) game. The second treatment is two sets of market parameters. Ten observations were collected for each cell. Each observation consists of sixty periods.

<table>
<thead>
<tr>
<th>Parameter Set One</th>
<th>Parameter Set Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha = 0.10$, $P = 80 - X$, $C = 20$</td>
<td>$\alpha = 0.10$, $P = 120 - X$, $C = 40$</td>
</tr>
<tr>
<td>Owners and Managers</td>
<td>Owners Only</td>
</tr>
<tr>
<td>Cell A</td>
<td>Cell B</td>
</tr>
</tbody>
</table>

Figure 2: Experimental Design and Cell Assignments.
The four player cells allow exploration of the weighted contract. Owners are able to implement their allocation strategy by selecting a weight ($\lambda$) to place on costs. The two player cells forces "true" ($\lambda = 1$) cost allocation (equivalent to accounting costs). Owners are no longer able to implement an allocation strategy. This eliminates owners ability to influence the output selections of both firms by the use of manager incentives. The parameter set manipulation is performed to verify that the results are not driven by a parameter quirk.

At the beginning of every session in cell A or cell B, the subjects are randomly assigned a role, either owner or manager. Next, one owner and one manager are randomly paired to form a firm. Then two firms are randomly grouped together to form a market. Each market remains grouped for the entire experiment. Subjects are not identified, so they have no way to determine which subjects are in their group. By repeating the game for sixty periods, the subjects have the opportunity to explore various strategies, learn how the game works, and learn how other subjects play the game. Subjects have the opportunity to update their beliefs about their rival firm's strategies and reputations may be formed. This may allow subjects to form reputations as cooperators, increasing the possibility of cooperation between owners, managers, or both.

In cells A and B, each period consist of two stages. In the first stage, each owner selects a contract to offer to their manager by selecting a cost allocation strategy ($\lambda_i$). The contract is a combination of firm revenues and firm costs. The owners select an allocation strategy by selecting a weight ($\lambda_i$) to place on costs
The resulting contract offered to the manager is a percentage \( \alpha \) of firm revenue \( (P_x \lambda - \lambda C) \) minus the allocated costs \( (\lambda C) \). After both owners have selected values for \( \lambda \), both contracts are revealed to all four participants. In the second stage, each manager selects an output level \( (x) \) for their firm. After both managers have selected \( x \), the market clearing price is determined \( (P = a - bX) \), the output from both firms is purchased by the market, manager compensation is calculated, and owner profit is determined. This process continues for sixty periods, then the subjects are paid and dismissed.

The owners may select values for \( \lambda \) that provide the managers with incentives to select the Nash equilibrium output, the monopoly output, the Cournot output, or any other desired output level. The only external restriction on \( \lambda \) is \( 0 < \lambda < 2 \). The restriction, \( \lambda > 0 \), is in place since a negative value for \( \lambda \) has a strange economic interpretation. When \( \lambda < 0 \), the owner is requesting their manager to select an output level that maximizes a weighted combination of revenue plus cost. This results in the owner rewarding the manager for increasing costs. If \( \lambda < -1 \), then the manager has compensation incentives that place more emphasis on maximizing cost than maximizing revenue. The

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11 As an alternative, owners could select the actual amount they want to allocate to their manager. For example, instead of selecting \( \lambda = .50 \) (when \( C = 20 \)), they could select an allocation cost of 10. However, since this range of allocated costs would be between 0 and 40, it was feared that the owners, managers or both would treat this as a procurement signal (owner selects cost of 10 so manager produces 10).

12 In the experiment, if \( P < C \), then no sales to the market took place. This policy was instituted due to results from the pilot study where managers could punish owners by selecting the maximum production of 80. This resulted in the owner losing approximately four days of Nash equilibrium profits in one day. At the end of the pilot experiments, several owners had negative point totals on hand due to this manager strategy.

13 A value of \( \lambda < 0 \) may be necessary to provide incentives leading to the competitive solution \( (P = C) \).
restriction, \( \lambda \leq 2 \), is included to prevent the optimal output level from becoming negative. The restraint on the manager’s selection of output is \( 0 \leq x_i \leq 80 \), where 80 is the maximum capacity of the firm.

The subjects, in cells A and B, are faced with two nested prisoner’s-dilemma-like games. The owners may attempt to reach the preferred (higher profit) monopoly outcome by cooperating and selecting \( \lambda_m \). Both owners have incentives to defect (select a value for \( \lambda_i < \lambda_m \)), to increase market share and profits at the rival firm’s expense. The managers may also cooperate in an attempt to increase their compensation, as shown in the numerical example, manager cooperation may be either beneficial or detrimental to the owners. Both managers have incentives to defect (by selecting a higher output level), to increase market share and compensation at the rival manager’s expense.

In cells C and D, each firm consists only of an owner.\(^\text{14}\) There is only one stage in cells C and D. The subjects select the output level for their firm and get to keep all of the firm’s profits. Next, the market clearing price is determined, the output from both firms is purchased by the market, and firm profit is calculated. This process continues for sixty periods, then the subjects are paid and dismissed.

These owner only cells provide a benchmark for comparison against the owner/manager cells. This may allow support for the model to be obtained even

\(^{14}\) Each firm could be considered to consist of a owner and manager with the subject being the manager who received a contract from the owner with \( \lambda = 1 \) in all periods. This alternative, in theory, should have no affect on the output levels selected by the subjects.
if the subjects do not play the predicted values for $x_i$ and $x_i$. Subjects are faced with one prisoner’s dilemma like game. Each owner privately selects an output level for their firm with the same restrictions on $x_i$, $0 \leq x_i \leq 80$. The owners may attempt to share the monopoly profits by restricting total output to the monopoly output level. In this case, the owners have incentives to defect (select higher output level), increasing market share and profits at the rival owner’s expense.

4.2 EXPERIMENTAL SESSION

Each session consisted of the same sequence of events: instructions, two practice periods, and the experiment.

4.2.1 INSTRUCTIONS AND PRACTICE PERIODS

Once all subjects arrive at the laboratory, they are given written instructions. Instructions for cells A through D are in Appendices L through O, respectively. The subjects are given approximately fifteen minutes to read the instructions. The instructions are then read aloud and subjects are permitted to ask questions regarding the experiment. Questions about strategy are not answered. After all subjects indicate they understand the instructions, they play two practice periods (conducted exactly as the regular experiment periods described in 4.2.2).

---

15 If the firms earn higher profits in the owner/manager cells then support may exist for the superiority of the weighted-contract over the quantity-contract.
The practice periods serve two purposes. First, the subjects learn which role they will play in the actual experiment. Subjects are given the same role in the practice periods as they will have in the actual experiment. Second, they learn how to input their decisions into the computer and how to understand the computer displays of each periods’ results. In the first practice period, they are given detailed instructions how to enter their selection of \( \lambda \) or \( x \). In cells A and B, the owners are told how to input their choice of \( \lambda_i \). The computer then displays both contracts to all four subjects. Next, in all cells, the managers are told how to input their choice of \( x_i \). The computer then calculates and displays the market price, the manager compensation, and the owner profits. These displays are explained to all subjects. Each subject sees the points earned by all subjects in their group for that period. A running total of points is also displayed of the subjects own points. Subjects are also reminded how these are calculated and told that they can verify the calculations if they wish. Once all questions are answered, they are allowed to play the second period at their own speed. If there are no further questions they are now allowed to start the experiment.
4.2.2 Experimental Sequence of Events

The following sequence of play is used in all experimental sessions:

1. **In cells A and B only:** Owners select a contract to offer their manager by selecting an allocation strategy, \( \lambda_i \).
2. **In cells A and B only:** Both contracts are revealed to all four subjects.
3. Managers select an output level for their firm, \( x_i \).
4. Both firms output levels are revealed.
5. The market clearing price is determined.
6. Profit and compensation for each subject is determined.
7. Point totals are displayed and each subject's running total is updated.

**Steps 1 and 2.** (Cells A and B) Owners simultaneously select the contract to offer their manager. The contract is determined by the cost allocation strategy selected by the owner. Once both owners select \( \lambda \), both contracts are revealed to all four subjects.

**Step 3 and 4.** The managers simultaneously select an output level for their firm. In the two player cells, one person acted as both firm owner and manager. Once an output level has been selected for both firms, the output levels are revealed to all subjects.

**Step 5.** The market clearing price \( P \) is determined by the inverse-demand function, \( P = a - bX \). This is the price that the firms receive for each unit of output they produced. If \( P < C \), then no production takes place and all subjects receive zero points for that period.

**Step 6.** In cells A and B, the manager compensation is calculated and the owner receives the residual profits of the firm. In cells C and D, the owner receives the firms' profits.
Step 7. The computer displays the points received by each subject. The subject's personal point total is now updated to reflect all periods played so far. If this is the sixtieth period the experiment ends, otherwise the sequence is started again from step one.

4.3 Subject Selection and Compensation

All subjects are selected from introductory and intermediate accounting courses at The Ohio State University. Sign-up is voluntary, the only compensation offered is the monetary earnings at the end of the experiment. Experiments are conducted on a computer network in a college of business laboratory.

The payments are designed so that subjects expect to earn the same amount of money if the Nash equilibrium holds. Since the managers receive a smaller amount of points each period, they receive more cash per point earned during the experiment. The ex-ante expected payments, if all subjects play the Nash equilibrium, range from twelve to fifteen dollars depending on the cell. The expected compensation is higher in the four player cells than in the two player cells since those experiments take a longer time period to complete. The subjects are paid in cash at the conclusion of the experiment.

Subjects were not allowed to communicate with each other during the experiment. The subjects were not identified during the experiment so they did
not know with which other subjects they were grouped. Subjects were not permitted to participate in more than one session of the experiment.
CHAPTER 5

RESEARCH HYPOTHESES

5.1 HYPOTHESES DEVELOPMENT

The equilibrium decisions are based on (10) and (13). In the four-player, owner-manager game, the owners are expected to offer contracts that under-allocate costs ($\lambda \leq 1$) to the managers based on (13).

$H_1$: In cells A and B, each owner will offer a contract to their manager by selecting an allocation strategy, $\lambda_i$, based on equation thirteen.

The managers' equilibrium output levels are described by (10). The managers are expected to select output levels that are decreasing in $\lambda_i$ and increasing in $\lambda_i$.

$H_{2A}$: In cells A and B, each manager will select an output level, $x_i$, based on (10) and the two contracts ($\lambda_i, \lambda_j$) selected by the owners.

In the two-player, owner-only game, the owners are competing in a Cournot environment. Thus, the expected output levels are expected to be the Cournot equilibrium output levels. These output levels are identical to the output levels predicted by (10) when $\lambda_1 = \lambda_i = 1$.

$H_{2B}$: In cells C and D, each owner will select an output level, $x_i$, based on equation ten, as if $\lambda_1 = \lambda_2 = 1$. 

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Related research (Fershtman and Judd [1987]) demonstrates that the weighted contract is superior to the standard profit-maximizing contract when uncertainty exists or when the owners are attempting to motivate the managers to implement predetermined firm strategies. Since no uncertainty exists in the model, the standard contract should provide the owners with higher profits than the weighted contract. However, if the owners are trying to motivate the managers to implement a certain strategy, such as sharing the monopoly profits, then the weighted-contract may be superior to the quantity-contract. Only firm profits are compared since the expected manager compensation could be set constant to the manager's opportunity wage by allowing the owner to solve for $\alpha$. This opportunity wage could be equal to zero which would equalize owner profits in the two and four player games.

$H_3$: Total firm profit will be higher in cell C (D) than in cell A (B).

Two sets of parameters are used in the experiment to avoid the possibility of the parameters driving the results. The offered contracts, output levels, and owner profits are expected to follow the predictions of (10) and (13), regardless of the parameter set.

$H_4$: The results for cells A and B (C and D) will be consistent.

### 5.2 Hypotheses Discussion

$H_1$ allows for testing of the allocation strategy selected by the owners. The hypothesis states that the owners will select the Nash equilibrium value for $\lambda$ as
predicted by (13). This value for $\lambda$ is less than one for both parameter sets. An examination of the theoretical model shows that this hypothesis should be accepted. The alternative to $H_1$ is that the owners will cooperate and select values for $\lambda$ greater than the Nash equilibrium value. If the owners select values for $\lambda$ greater than the Nash value, then there may be support for owner cooperation. This would lead to the rejection of $H_1$.

Two ideas may be tested by $H_{2a}$. First, do managers select the predicted Nash equilibrium output levels predicted by equation ten. It has been suggested, that a reason for using the weighted contract, is that it may allow an owner to positively influence the output decisions of the rival firm. This may be tested for by regression analysis using both contracts as independent variables and the output levels as dependent variables. Second, manager cooperation may be examined. Cooperation by the managers requires output to be below the Nash equilibrium level. The theoretical model predicts that the hypothesis should be accepted. The hypothesis might be rejected if the managers fail to respond to the contract selected by the rival firm. Managers might fail to understand the interaction effects and base their output decisions solely on their own contract. Another reason for rejection is that managers may not hold Cournot beliefs. If this is the case, then alternative models will need to be examined. One such alternative model is Dockner's [1992] theory of conjectural variations.
$H_{2a}$ allows testing of the quantity contract. The hypothesis predicts that owners will select the standard Cournot equilibrium output levels \((10)\) with \(\lambda_1 = \lambda_2 = 1\). The alternative to this hypothesis is that the owners cooperate and select output levels that lead to higher profits. Comparison of the cooperation results from $H_1$ and $H_{2a}$ may help answer the question of whether the weighted contract makes cooperation easier to obtain.

Testing of $H_3$ is quite important. This hypothesis states that the quantity contract should outperform (provide higher profits) than the weighted contract in this setting. The model predicts that $H_3$ should be accepted. Rejection of this hypothesis has strong implications. If the weighted contract is superior without uncertainty, as required by FJ, then support for the cooperation property of the weighted contract may exist. It may also suggest that the weighted contract may superior due to its ability to aid in strategy implementation or its ability to favorable influence the actions of the rival firm. Assuming the hypothesis holds, the next step might include experimenting with a model that includes uncertainty.

The last hypothesis is designed to ensure that the parameter set selected does not drive all of the results. If $H_4$ is accepted, it does not guarantee that the results will hold for all parameter sets. Rather it implies that the results hold for at least a range of parameter sets. If the hypothesis is rejected, then further examination of the parameters and their effects should be pursued.

---

16 The two player game (cells C and D) is equivalent to the quantity contract. The output level selected by the owner may be interpreted as the quantity that the owner would offer in a contract to the manager. A
CHAPTER 6
ANALYSIS OF RESULTS

6.1 $H_1$

The following table describes the data for $\lambda$ in cells A and B (histograms of the data are in Appendix F):

<table>
<thead>
<tr>
<th></th>
<th>Predicted Value for $\lambda$</th>
<th>Mean Value of $\lambda$</th>
<th>Median Value of $\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell A</td>
<td>0.67</td>
<td>1.08</td>
<td>1.05</td>
</tr>
<tr>
<td>Cell B</td>
<td>0.78</td>
<td>0.91</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 3: Description of $\lambda$ for cells A and B.

$H_1$: In cells A and B, each owner will offer a contract to their manager by selecting an allocation strategy, $\lambda_i$, based on (13).

The main question of $H_1$ is whether the owners offer the competitive Nash equilibrium contracts or whether the owners offer cooperative contracts in an attempt to earn higher profits. In both cells, the owners offered contracts with $\lambda$. 

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values that are statistically higher (more cooperative) than the Nash equilibrium contracts (p-values of 0.0000).

In cell A, the contracts are meaningfully different than the predicted contracts. The $\lambda$ values for these contracts are statistically higher than the Cournot contracts of $\lambda = 1$ (p-value of 0.0000). The output levels and firm profit levels are consistent with the contracts offered. The output levels for cell A are lower than the output levels for the Cournot game and the resulting firm profits are higher than the firm profits of the Cournot game. Owners in cell A, achieve cooperation and earn higher profits than the Cournot game. Although cooperation is not at the monopoly level, it is high enough that the owners benefit from hiring a manager and offering the weighted-contract. Cell A provides a strong basis for rejecting $H_1$.

In cell B, the $\lambda$ values of the contracts offered are statistically lower than the Cournot level (p-value of 0.0000). The output levels and firm profits are consistent with the contracts offered which give the managers incentives to be aggressive. Output levels are higher and firm profits lower than in the Cournot game. Cooperation appears to exist in cell B, but not at a level high enough to offset the expense of hiring of a manager. Cell B provides a weak basis for rejecting $H_1$.

Examination of the results lead to the rejection of $H_1$. Owners do not offer the Nash equilibrium contracts to their managers. Instead, owners cooperate by
offering weighted-contracts that provide managers with incentives to reduce output levels in order to increase firm profits.

6.2 $H_{2A}$ AND $H_{2B}$

The following table describes the data for $x$ in cells A, B, C, and D (histograms of the data are in Appendix G):

<table>
<thead>
<tr>
<th></th>
<th>Predicted Value for $x$</th>
<th>Mean Value of $x$</th>
<th>Median Value of $x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell A</td>
<td>22.22</td>
<td>23.02</td>
<td>22.00</td>
</tr>
<tr>
<td>Cell B</td>
<td>29.63</td>
<td>33.57</td>
<td>32.00</td>
</tr>
<tr>
<td>Cell C</td>
<td>20.00</td>
<td>23.59</td>
<td>25.00</td>
</tr>
<tr>
<td>Cell D</td>
<td>26.67</td>
<td>29.88</td>
<td>30.00</td>
</tr>
</tbody>
</table>

Table 4: Description of $x$ for cells A, B, C, and D.

$H_{2A}$: In cells A and B, each owner will select an output level, $x_i$, based on (10) and the two contracts selected by the owners.

The managers are expected to select output levels based on the contract they are offered and on the contract their rival is offered. As the $\lambda$ value in a manager's contract increases, the manager's output level is expected to decrease. As the $\lambda$ value in the rival manager's contract increases, the
manager's output level is expected to increase. The reaction to the manager's own contract is expected to be twice as strong as the reaction to the rival manager's contract.

Using the parameters in cell A, the predicted output level given the two contracts, based on (10), is as follows: \( x_i = 26.67 - (13.33)\lambda_i + (6.67)\lambda_j \). The equation resulting from regressing \( x_i \) on \( \lambda_i \) and \( \lambda_j \) is as follows: \( x_i = 27.50 - (2.74)\lambda_i - (1.42)\lambda_j \). The sign on the coefficient of the manager’s own contract is in the predicted direction but the magnitude is smaller than predicted (p-value = 0.000). The sign on the coefficient of the rival manager’s contract is opposite of the predicted direction and the magnitude is smaller than predicted (p-value = 0.031). The managers appear to be reacting to their own contracts, although, not as strongly as predicted. The reaction to the rival manager’s contract is opposite of the prediction.

It is possible that the managers sent signals to the owners when an unacceptable contract was offered. To test for this possibility, any data points with an output level less than ten or greater than forty were removed and the regression re-run. The new equation is as follows: \( x_i = 28.1 - (2.87)\lambda_i - (1.89)\lambda_j \). The results of this regression are completely consistent with the results of the full data set regression (p-value on both coefficients are 0.000).

Substituting the parameters of cell B into (10) provides the following equation: \( x_i = 40.0 - (26.67)\lambda_i + (13.33)\lambda_j \). The regression of the full data set produced the following equation: \( x_i = 36.6 - (3.53)\lambda_i + (0.219)\lambda_j \). The signs on
both coefficients are as predicted and the magnitudes of both coefficients are smaller than predicted. The coefficient on $\lambda_j$ is significant (p-value = 0.000) but the coefficient on $\lambda_i$ is not significant (p-value = 0.801). In cell B, the managers appear to use their own contract while ignoring their rival's contract when selecting output levels.

When the regression was re-run, removing the extreme data points, the following equation was obtained: $x_j = 34.1 - (3.07)\lambda_i + (0.352)\lambda_j$. This equation is consistent with the equation based on the full data set. The coefficient on $\lambda_i$ is significant (p-value = 0.000) but the coefficient on $\lambda_j$ is not significant (p-value = 0.565).

The results suggest that the managers in both cells use to their own contracts when selecting output levels, although they did not react as strongly as the model predicts. The managers in cell A react to the rival manager's contract in a manner opposite to the prediction. The model predicts that making your manager more aggressive will make the rival manager less aggressive. In the cell A, providing your manager with aggressive incentives also made the rival manager more aggressive. In cell B, the managers do not appear to give any weight to the rival manager's contract when selecting output levels.

The plots of output levels versus contracts (Appendices H and I) and the normal plots (Appendices J and K) both support the idea that the managers do not respond to the contracts offered when selecting output levels. The results of the plots and the regression analysis lead to the rejection of $H_{2A}$. 
\[ H_{2B}: \text{ In cells C and D, each owner will select an output level, } x_i, \text{ based on equation ten, as if } \lambda_1 = \lambda_2 = 1. \]

The predicted output levels for the two-player game in cells C and D are the solution to the standard Cournot game. In both cells, the owner-only firms overproduced compared to the Cournot predictions (p-values of 0.0000). This overproduction results in lower than expected profits for the owner-only firms. Since the owners do not produce at the Cournot levels (\( \lambda_1 = \lambda_2 = 1 \)), the hypothesis \( H_{2B} \) is rejected.

6.2.3 \( H_3 \)

The following table describes the data for firm profits in cells A, B, C, and D:
### Table 5: Description of Firm Profits for cells A, B, C, and D.

<table>
<thead>
<tr>
<th>Cell</th>
<th>Mean of Firm Profit</th>
<th>Median of Firm Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell A</td>
<td>289.03</td>
<td>306.00</td>
</tr>
<tr>
<td>Cell B</td>
<td>410.60</td>
<td>375.00</td>
</tr>
<tr>
<td>Cell C</td>
<td>257.18</td>
<td>250.00</td>
</tr>
<tr>
<td>Cell D</td>
<td>516.00</td>
<td>548.00</td>
</tr>
</tbody>
</table>

**H3:** Total firm profit will be higher in cell C (D) than in cell A (B).

The cells using the quantity-contract are expected to outperform the cells using the weighted-contract in this model. Testing the data leads to mixed results. Cell A firms earn higher profits than cell C firms (p-value of 0.000). This leads to rejection of hypothesis H3 under parameter set one. Cell D firms earn higher profits than cell B firms (p-value of 0.000). This leads the acceptance of H3 under parameter set two.

The conflicting results could be driven by the parameter set or by the subjects. There may be some yet undiscovered factor that allows parameter set one to be more favorable to the weighted-contract. Cell D subjects shared the monopoly profits more frequently than the subjects in any other cell. Whether the
results are driven by one of the reasons is a question that needs further exploration.

6.2.4 $H_4$

$H_4$: The results for cells A and B (C and D) will be consistent.

The results of the other Hypotheses lead to the rejection of $H_4$. The results of the experiment are not consistent across parameter sets. The conclusions of $H_3$ are opposite across the parameter sets. Under parameter set one, $H_3$ is rejected. Under parameter set two, $H_3$ is accepted. The results for $H_1$ also vary across the parameter sets. With parameter set one (two), the four-player game achieves more (less) cooperation than the two-player game. While managers react similarly to their own contract when selecting output levels under both parameter sets, they react differently to their rival manager's contract. Parameter set one managers respond to their rival manager's contract in the same direction that the rival responds (both become more or less aggressive). Parameter set two managers appear to ignore their rival manager's contract.

Only the results of $H_{2B}$ are consistent with $H_4$. Both parameter sets led to overproduction by the owner-only firms.
Chapter 7

Summary and Conclusions

7.1 Conclusions

Observations based on the results suggest that the subjects, particularly the managers, may be having trouble understanding the effects of the contracts offered in cells A and B. While owners appear to be exhibiting some degree of cooperation, the managers almost appear to be picking output levels at random. This may be due to the complexity of the interaction between the contracts offered and the corresponding optimal output levels. This makes the results difficult to interpret.

The firms welfare was not the same between the two contracting options. The weighted-contract outperformed the quantity-contract under parameter set one but the quantity-contract outperformed the weighted-contract under parameter set two. The managers failure to react to the contracts as predicted may make this result stronger. The managers, according to the regression analysis, did react as in the direction expected to the rival manager's contract under parameter set one. The weighted-contract in cell A outperformed the corresponding quantity-contract in cell C. The weighted-contracts' ability to
influence the rival manager's output levels may be the cause of the superior performance of the weighted-contract under parameter set one.

There is considerable variation between the performance of the different groups. Within each cell, some groups managed much higher profits than others. There may be some unknown attribute of the subjects that allowed some of them to perform better than others. Several groups were able to share monopoly profits in multiple periods. Some groups never obtained the monopoly profits and experienced many periods where nobody made any positive profit.

This experiment demonstrates that it is possible for the weighted-contract to outperform the quantity-contract even when no uncertainty exists. This may due to the weighted-contracts ability to change the rival manager's selection of output levels in a positive way.

7.2 Future Research

Future research might include modification of the experiment in an attempt to increase subject understanding of the relationship between the contracts and output levels. An interesting possibility is a four player game where two subjects play the role of the owners while the computer simulates the role of the managers. The computer would select the output levels according to equation ten and the two contracts offered by the owners. This experiment would decrease the difficulty level. Owners might have an easier time understanding the relationship between the contracts they offer and the output levels selected by
the managers. Since the managers did not seem to respond to the contracts offered, especially the rival manager's contract, this is the next area of experimentation to be explored.

Other possible alternatives include having the subjects playing the owner-only game first, and then returning to play the manager/owner game. This might allow the subjects to have a better understanding of the market and allow them to concentrate on the impact of the contracts. Subjects could also be given the opportunity to play both roles in the experiment. Another alternative is to only allow the owners to offer a new contract every "x" periods. By allowing the managers to repeat play with the same contracts, they may have a better opportunity to learn about the contract effects. If only one owner is allowed to select a new contract during any particular period, the managers may realize the effects that both contracts have on their optimal output level. Providing the Cournot solution to the players of the manager/owner game might provide them with a starting point from which managers could then modify output to adjust to the changing contracts being offered by the owners.

Uncertainty could be introduced in the demand function or the production costs. The uncertainty may allow the weighted contract to outperform the quantity contract. The contract could be redesigned by placing the weight on revenue instead of cost. Bertrand competition could replace Cournot competition. Sklivas found that the weighted contract outperformed the quantity contract under Bertrand competition, even when uncertainty was not present. The
implementation of Bertrand competition may have complexities of its own. It might be useful to expand the experiment to an oligopoly instead of a duopoly. Finally, an attempt to implement conjectural variations might prove useful. Conjectural variations might be able to be used to determine the prior beliefs of the subjects. That way, if the subjects do not have Cournot beliefs, a more appropriate model may be implemented for the experiment.
APPENDIX A

AN EXAMPLE OF THE EFFECTS OF $\alpha$

The managers' contract is $\alpha(Px_i - CX_i)$. Since $\alpha$ is just a scalar on the managers' contracts, the managers' selection of $x_i$ is not affected by changes in $\alpha$, ceteris paribus. The owners selection of $\lambda_i$ is dependent on $\alpha$, see (13). The following table shows the resulting optimal contracts ($\lambda_i$) and the resulting profits for some selected values of $\alpha$ (using parameter set one):

<table>
<thead>
<tr>
<th>$\alpha$</th>
<th>0.01</th>
<th>0.10</th>
<th>0.20</th>
<th>0.25</th>
<th>0.30</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_i$</td>
<td>0.43</td>
<td>0.67</td>
<td>0.90</td>
<td>1.00</td>
<td>1.10</td>
<td>1.43</td>
<td>1.75</td>
<td>2.00</td>
</tr>
<tr>
<td>$x_i$</td>
<td>23.81</td>
<td>22.22</td>
<td>20.69</td>
<td>20.00</td>
<td>19.35</td>
<td>17.14</td>
<td>15.00</td>
<td>13.33</td>
</tr>
<tr>
<td>Firm Profit</td>
<td>294.78</td>
<td>345.68</td>
<td>385.25</td>
<td>400.00</td>
<td>412.07</td>
<td>440.82</td>
<td>450.00</td>
<td>444.44</td>
</tr>
<tr>
<td>Manager Compensation</td>
<td>5.67</td>
<td>49.38</td>
<td>85.61</td>
<td>100.00</td>
<td>112.38</td>
<td>146.94</td>
<td>168.75</td>
<td>177.77</td>
</tr>
<tr>
<td>Owner Profit</td>
<td>289.11</td>
<td>296.30</td>
<td>299.64</td>
<td>300.00</td>
<td>299.69</td>
<td>293.88</td>
<td>281.25</td>
<td>266.67</td>
</tr>
</tbody>
</table>

Table 6: Results of different $\alpha$ values.

The optimal value for $\alpha$ for the owner is $\alpha = 0.25$. This is equivalent to the Cournot solution ($\lambda_i = 1$ and $x_i = 20$), but the owner has to share 25% of the firm profits with the manager. The firm profit is maximized when $\alpha = 0.75$. This is
equivalent to the monopoly solution \( (x_i = 15) \), but the owner has to give the manager 75% of the firm profits and is thus better off mimicking the Cournot solution.

The firm's profit is increasing in \( \alpha \) for \( 0 \leq \alpha \leq 1 \). The owner's profit is increasing in \( \alpha \) for \( 0 \leq \alpha \leq 0.25 \), but is decreasing in \( \alpha \) for \( 0.25 \leq \alpha \leq 1 \). The owners benefit from collusion (selecting a \( \lambda \) that promotes the monopoly output) when \( 0 \leq \alpha \leq 0.5 \). When \( \alpha > 0.5 \), owner collusion is not in the best interest of the owners.
Appendix B

Subgame-Perfect Equilibria

\( \lambda_i \) = the weight factor chosen by the owner \( i \).
\( C \) = firms cost to produce one unit. This is constant and the same for each firm.
\( P \) = price = \( a - bX \). This is the market clearing price.
\( X \) = total market production = \( x_i + x_j \)
\( \alpha \) = the percentage of modified profits that the manager receives.

Each manager needs to solve the following problem:

\[
\begin{align*}
& \text{Max } \alpha(Px_i - \lambda_iCx_i) \\
& \text{Max } \alpha x_i(a - bx_i - bx_j - \lambda_iC)
\end{align*}
\]

Each owner needs to solve the following problem:

\[
\begin{align*}
& \text{Max } Px_i - Cx_i - \alpha(Px_i - \lambda_iC x_i) \\
& \text{Max } x_i[(1 - \alpha)(a - bx_i - bx_j) + C(\alpha\lambda_i - 1)]
\end{align*}
\]

First, solve the managers problem for \( x_i \) in terms of \( \lambda_i, a, b \) and \( C \).
This yields \( x_i = \frac{a + C(\lambda_i - 2\lambda_j)}{3b} \) and \( x_j = \frac{a + C(\lambda_i - 2\lambda_j)}{3b} \).

Second, solve the owners problem for \( \lambda_i \) in terms of \( a, b, \) and \( C \), substituting in the solutions of \( x_i \) achieved above.
This yields \( \lambda_i = \lambda_j = \frac{[(12\alpha + 3)(6C - a + 4\alpha a)]}{[C(48\alpha^2 + 72\alpha + 15)]} \)

Further details and complete solution available from the author.
APPENDIX C
MONOPOLY SOLUTION

\begin{align*}
\lambda_i &= \text{the weight factor chosen by the owner } i. \\
C &= \text{firms cost to produce one unit. This is constant and the same for each firm.} \\
P &= \text{price } = a - bX. \text{ This is the market clearing price.} \\
X &= \text{total market production } = x_i + x_j \\
\alpha &= \text{the percentage of modified profits that the manager receives.}
\end{align*}

In this case the owners are trying to cooperate so they can share the monopoly profits. Thus each owner wants to motivate their manager to pick an output equal to \( \frac{1}{2} \) the monopoly quantity. First we find the monopoly production level. This yields:

\[
X = \frac{a(1 - \alpha) - C(1 - \alpha \lambda)}{2b(1 - \alpha)}
\]

Then find each firms individual output level. Each firm is to produce \( \frac{1}{2} \) the output yielding:

\[
x_i = x_j = \frac{a(1 - \alpha) - C(1 - \alpha \lambda)}{4b(1 - \alpha)}
\]

The owners now needs to determine what \( \lambda_i \) to select so that the managers will each select output equal to half of the monopoly quantity. To reach these output levels, both owners need to select the same \( \lambda_i \). This changes the managers response function(from Appendix A) to \( x_i = x_j = \frac{(a - C \lambda)}{3b} \). The owners wish to motivate the managers to pick the monopoly output so we set the monopoly output equal to the managers output function, \( \frac{a(1 - \alpha) - C(1 - \alpha \lambda)}{4b(1 - \alpha)} = \frac{(a - C \lambda)}{3b} \). This yields:

\[
\lambda_m = \frac{a(1 - \alpha) + 3C}{C(4 - \alpha)}
\]

So, if both owners set \( \lambda_m = \frac{a(1 - \alpha) + 3C}{C(4 - \alpha)} \), then the monopoly solution can be reached if the managers select output using their best-response function.
APPENDIX D

MANAGERS COOPERATION

\( \lambda_i \) = the weight factor chosen by the owner \( i \).
\( C \) = firms cost to produce one unit. This is constant and the same for each firm.
\( P \) = price = \( a - bX \). This is the market clearing price.
\( X \) = total market production = \( x_i + x_j \)
\( \alpha \) = the percentage of modified profits that the manager receives.

In this case, the managers are trying to cooperate to increase the value of their objective function. This may be accomplished by each manager producing one-half of the output that maximizes their combined objective functions. This is achieved by solving their objective function as if there was only one firm producing (assuming that both firms have the same \( \lambda \)).

\[
\begin{align*}
\text{Max } \alpha(PX - \lambda CX) \\
\text{Max } \alpha(aX - bX^2 - \lambda CX)
\end{align*}
\]

This yields \( X = (a - \lambda C) / 2b \). Each manager produces half so \( x_i = x_j = (a - \lambda C) / 4b \). This is a lower level of output than the earlier determined \( x_i = (a - \lambda C) / 3b \).

If the managers cooperate and produce at this lower level they maximize their compensation. The each have incentives to defect and produce a higher output level to increase their profits at the expense of the other manager.

Further details and complete solution available from the author.
APPENDIX E

NUMERICAL EXAMPLE FOR PARAMETER SET TWO.

Parameters

\[ \alpha = .10 = \text{managers percentage of firm's weighted profits} \]

\[ P = a - bX = 120 - X = \text{market clearing price} \]

\[ X = x_1 + x_2 = \text{total market production} \]

\[ C = 40 = \text{marginal cost to produce one unit} \]

\[ \lambda = \text{the weight placed on } C, \text{ selected by each owner} \]
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_i$</td>
<td>.78</td>
<td>.78</td>
<td>1.0</td>
<td>1.0</td>
<td>1.46</td>
<td>1.46</td>
</tr>
<tr>
<td>$x_i$</td>
<td>29.63</td>
<td>22.22</td>
<td>26.67</td>
<td>20</td>
<td>20.51</td>
<td>15.38</td>
</tr>
<tr>
<td>$P = a - bX$</td>
<td>60.74</td>
<td>75.56</td>
<td>66.67</td>
<td>80</td>
<td>78.98</td>
<td>89.24</td>
</tr>
<tr>
<td>Firm Profit</td>
<td>614.53</td>
<td>790.14</td>
<td>711.29</td>
<td>800</td>
<td>799.27</td>
<td>757.31</td>
</tr>
<tr>
<td>Manager</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compensation</td>
<td>87.79</td>
<td>98.76</td>
<td>71.13</td>
<td>80</td>
<td>42.08</td>
<td>47.34</td>
</tr>
<tr>
<td>Owner Profit</td>
<td>526.74</td>
<td>691.38</td>
<td>640.16</td>
<td>720</td>
<td>757.19</td>
<td>709.97</td>
</tr>
</tbody>
</table>

Table 7: Numerical example for parameter set two. All numbers in the table have been rounded to two decimal places.
APPENDIX F

HISTOGRAMS FOR $\lambda$ VALUES

Figure 3: Histogram of lambda values for cell A.
Figure 4: Histogram of Lambda values for cell B.
APPENDIX G

HISTOGRAMS FOR x VALUES

Figure 5: Histogram of output levels (x) for cell A.
Figure 6: Histogram of output levels for cell B.

Figure 7: Histogram of output levels for cell C.
Figure 8: Histogram of output levels for cell D.
Figure 9: Plot of output as a function of the manager’s contract for cell A.
Figure 10: Plot of output as a function of the rival manager's contract for cell A.
APPENDIX I

PLOTS OF OUTPUT LEVELS VERSUS CONTRACTS FOR CELL B

Figure 11: Plot of output as a function of the manager's contract for cell B.
Figure 12: Plot of output as a function of the rival manager's contract for cell B.
APPENDIX J

NORMAL PLOTS OF DATA FOR CELL A

Figure 13: Normal plot of output levels for all data in cell A.
Figure 14: Normal plot of output levels for the signal-reduced data in cell A.
APPENDIX K

NORMAL PLOTS OF DATA FOR CELL B

Figure 15: Normal plot of output levels for all data in cell B.
Figure 16: Normal plot of output levels for the signal-reduced data in cell B.
APPENDIX L

INSTRUCTIONS FOR CELL A

Instructions for all participants.

Experiment
Please do not communicate with any of the other participants!

In this game, you will be either the owner of a firm or the production manager of a firm, determined later at random. Each firm in the game is identical. Each firm consists of one owner and one production manager, produces an identical product, and has identical production costs. The owner's job is to select a compensation package for the manager each period (round) of the game. The production manager's job is to select how many units of output (x) the firm will produce each period.

There are two firms in each market, your firm and one other firm. At the beginning of the game, you will be randomly paired with another participant to form a firm (one owner and one production manager). Then your firm will randomly be paired with another firm to form a market. The four participants in the market will remain grouped together and each participant will retain the same job for the entire game.
Sequence of play

1. At the beginning of the game, you are randomly assigned to be either an owner or a manager. Then you are paired with another subject to form a firm. Finally, two firms are paired together to form a market.

2. Both owners simultaneously and privately select compensation packages for their manager (explained later in the instructions).

3. After learning both their own contract and the other manager's contract, each manager simultaneously and privately select an output level (x) for their firm.

4. The market clearing price (explained later) is determined and the market purchases output.

5. Manager compensation and owner profit for the current period are calculated.

6. If this is the sixtieth period the game ends, else go back to step 2.

Each unit produced by your company costs 20 to make. Thus if you produce 2 units, your total production costs are 40. The minimum number of units each firm can produce every round is 0, the maximum number of units is 80.

The market will purchase all of the units produced by both firms. The price that will be paid depends on the total production of both firms. The market price will hereafter be referred to as P.

\[ P = 80 - x_1 - x_2 \]

- \( x_1 \) is the production level of your firm.
- \( x_2 \) is the production level of the other firm.

If \( P < 20 \), neither firm will not sell any units to the market.

The owner receives their firm profits each round. The firm profits are revenue minus production costs minus manager compensation. Firm profit might be negative, zero, or positive. The equation to calculate firm profit is the following:

\[ P \times x_1 - 20 \times x_1 - \text{manager compensation} \]

- \( P \) = the market price
- \( x_1 \) = the output of your firm
- 20 = the cost to produce one unit
The manager receives compensation each round of the game. The compensation is based on the contract provided by the owner. This contract is based on firm profits but may be modified by the owner. The owner modifies the manager's contract by selecting a weight to place on the production costs. Thus the owner may charge the production costs to the manager at the actual cost of 20 per unit, at a cost less than 20 per unit, or at a cost more that 20 per unit. The owner does this by selecting a weight (C). This minimum value for this weight is 0% and the maximum is 200%. Thus costs may be charged at any rate between 0 and 40 per unit. The manager's compensation contract is as follows:

\[(0.1) \times (P^*x_1 - C^*20^*x_1)\]

\[C = \text{weight selected by owner}\]

\[(0.1)\] is the percentage of modified firm profits the manager receives.

At the beginning of each round, both owners privately select a value for C. This determines their manager's contract for that round. After both owners have selected values for C, all four participants find out the values of C that have been selected by both owners. Next, both managers select output levels for their firm. Once both managers have selected output levels, then the output levels of both firms are revealed, P is calculated, manager compensation is calculated, and owner profits are calculated.

Here is an example to give you an idea how the game works. This example is NOT meant to give you any information about how you should play the game.

<table>
<thead>
<tr>
<th>Each owner selects a value for C.</th>
<th>Firm 1</th>
<th>Firm 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>The resulting manager compensation contracts.</td>
<td>((0.1) \times (P^*x_1))</td>
<td>((0.1) \times (P^*x_2 - 40^*x_2))</td>
</tr>
<tr>
<td>Each manager picks an output level.</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>P is calculated.</td>
<td>(P = 80 - x_1 - x_2) [= 80 - 2 - 8 = 70]</td>
<td>(P = 80 - x_1 - x_2) [= 80 - 2 - 8 = 70]</td>
</tr>
<tr>
<td>Manager compensation is calculated.</td>
<td>((0.1) \times (70^*2) = 14)</td>
<td>((0.1) \times (70^*8 - 40^*8) = 24)</td>
</tr>
<tr>
<td>Owner profit is calculated.</td>
<td>(P^*x_1 - 20^*x_1 - \text{manager compensation} = 70^*2 - 20^*2 - 14 = 86)</td>
<td>(P^*x_1 - 20^*x_1 - \text{manager compensation} = 70^*8 - 20^*8 - 24 = 376)</td>
</tr>
</tbody>
</table>
At the end of the game you will receive cash. The owners will receive 1 cent per every 12 points that you earn. The managers will receive 1 cent per 2 point that you earn. Payments will be rounded to the nearest nickel.

If you have any questions, please ask me now or at any time they arise during the game. As a reminder, please do not communicate with any of the other participants during the game.
APPENDIX M

INSTRUCTIONS FOR CELL B

Instructions for all participants.

Experiment
Please do not communicate with any of the other participants!

In this game, you will be either the owner of a firm or the production manager of a firm, determined later at random. Each firm in the game is identical. Each firm consists of one owner and one production manager, produces an identical product, and has identical production costs. The owner’s job is to select a compensation package for the manager each period (round) of the game. The production manager’s job is to select how many units of output (x) the firm will produce each period.

There are two firms in each market, your firm and one other firm. At the beginning of the game, you will be randomly paired with another participant to form a firm (one owner and one production manager). Then your firm will randomly be paired with another firm to form a market. The four participants in the market will remain grouped together and each participant will retain the same job for the entire game.
Sequence of play

1. At the beginning of the game, you are randomly assigned to be either an owner or a manager. Then you are paired with another subject to form a firm. Finally, two firms are paired together to form a market.

2. Both owners simultaneously and privately select compensation packages for their manager (explained later in the instructions).

3. After learning both their own contract and the other manager’s contract, each manager simultaneously and privately select an output level \( x \) for their firm.

4. The market clearing price (explained later) is determined and the market purchases output.

5. Manager compensation and owner profit for the current period are calculated.

6. If this is the sixtieth period the game ends, else go back to step 2.

Each unit produced by your company costs 40 to make. Thus if you produce 3 units, your total production costs are 120. The minimum number of units each firm can produce every round is 0, the maximum number of units is 80.

The market will purchase all of the units produced by both firms. The price that will be paid depends on the total production of both firms. The market price will hereafter be referred to as \( P \).

\[
P = 120 - x_1 - x_2
\]

\( x_1 \) is the production level of your firm.

\( x_2 \) is the production level of the other firm.

If \( P < 40 \), neither firm will not sell any units to the market.

The owner receives their firm profits each round. The firm profits are revenue minus production costs minus manager compensation. Firm profit might be negative, zero, or positive. The equation to calculate firm profit is the following:

\[
P \cdot x_1 - 40 \cdot x_1 - \text{manager compensation}
\]

\( P = \) the market price

\( x_1 = \) the output of your firm

40 = the cost to produce one unit
The manager receives compensation each round of the game. The compensation is based on the contract provided by the owner. This contract is based on firm profits but may be modified by the owner. The owner modifies the manager's contract by selecting a weight to place on the production costs. Thus the owner may charge the production costs to the manager at the actual cost of 40 per unit, at a cost less than 40 per unit, or at a cost more that 40 per unit. The owner does this by selecting a weight \((C)\). This minimum value for this weight is 0% and the maximum is 200%. Thus costs may be charged at any rate between 0 and 80 per unit. The manager's compensation contract is as follows:

\[
(0.1) \times (P \times x_1 - C \times 40 \times x_1)
\]

\(C\) = weight selected by owner

\(0.1\) is the percentage of modified firm profits the manager receives.

At the beginning of each round, both owners privately select a value for \(C\). This determines their manager's contract for that round. After both owners have selected values for \(C\), all four participants find out the values of \(C\) that have been selected by both owners. Next, both managers select output levels for their firm. Once both managers have selected output levels, then the output levels of both firms are revealed, \(P\) is calculated, manager compensation is calculated, and owner profits are calculated.

Here is an example to give you an idea how the game works. This example is NOT meant to give you any information about how you should play the game.

<table>
<thead>
<tr>
<th></th>
<th>Firm 1</th>
<th>Firm 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each owner selects a value for (C).</td>
<td>0%</td>
<td>200%</td>
</tr>
<tr>
<td>The resulting manager compensation contracts.</td>
<td>((0.1) \times (P \times x_1))</td>
<td>((0.1) \times (P \times x_2 - 40 \times x_2))</td>
</tr>
<tr>
<td>Each manager picks an output level.</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>(P) is calculated.</td>
<td>(P = 80 - x_1 - x_2) = 80 - 2 - 8 = 110</td>
<td>(P = 80 - x_1 - x_2) = 80 - 2 - 8 = 110</td>
</tr>
<tr>
<td>Manager compensation is calculated.</td>
<td>((0.1) \times (110 \times 2) = 22)</td>
<td>((0.1) \times (110 \times 8 - 80 \times 8) = 24)</td>
</tr>
</tbody>
</table>
| Owner profit is calculated. | \(P \times x_1 - 40 \times x_1 - \) manager compensation  
\(= 110 \times 2 - 40 \times 2 - 22\)  
\(= 118\) | \(P \times x_1 - 40 \times x_1 - \) manager compensation  
\(= 110 \times 8 - 40 \times 8 - 24\)  
\(= 536\) |
At the end of the game you will receive cash. The owners will receive 1 cent per every 20 points that you earn. The managers will receive 1 cent per 4 point that you earn. Payments will be rounded to the nearest nickel.

If you have any questions, please ask me now or at any time they arise during the game. As a reminder, please do not communicate with any of the other participants during the game.
APPENDIX N

INSTRUCTIONS FOR CELL C

Instructions for all participants.

Please do not communicate with any of the other participants!

In this experiment, you will be the owner of a firm. Each firm in the experiment is identical, consists of one owner, produces an identical product, and has identical production costs. As the owner of your firm, you are responsible for deciding how many units of output your firm will produce.

There are two firms in each market, your firm and one other firm. At the beginning of the experiment, you will be paired with a firm selected at random from the other participants and will remain paired with that firm for the entire experiment. At the beginning of each period (round), each owner will simultaneously and privately pick output levels (x) for their firm. Once both owners have selected output levels, the market will purchase all production from both firms at the market clearing price (P), which is explained later in the instructions. The profits for each firm will then be calculated. As the owner you retain all of your firm’s profits (revenue minus production cost). You will be compensated at the end of the experiment based on the total profit earned by your firm. The experiment will last for sixty (60) periods.

The market-clearing price is determined as follows:

\[ P = 80 - x_1 - x_2 \]

The minimum value for P is zero.
\( x_1 \) is the output level for your firm.
\( x_2 \) is the output level for the other firm.
The cost of production for each firm is 20. Each and every unit your firm produces, costs your firm 20. The profits for your firm are calculated as follows:

\[ \text{Profit} = P \times x_i - 20 \times x_i \]

If the selling price \( P \) is less than 20, then no sales take place.

Example: Your firm produces 10 units and the rival firm produces 25 units. The market clearing price would be: \( P = 80 - 10 - 25 = 45 \). Since the market price is NOT less than 20, both firms produce their units and sell them to the market for 45 each.

The profit for your firm would be \( 45 \times 10 - 20 \times 10 = 250 \).

**Review of sequence of play**

1. Your firm is randomly paired with another firm at the beginning of the experiment.
2. Both owners simultaneously and privately select output levels.
3. The market clearing price is determined and the market purchases all output.
4. Both firms' profits are calculated for the current period.
5. If this is the sixtieth period the experiment ends, else go back to step 2.

At the end of the experiment you will receive cash. You will receive 1 cent per every 20 points earned, rounded to the nearest nickel. For example, if you accumulate 12857 points you get \( 12857/20 \) which is $6.43 rounded to the nearest nickel is $6.45.

If you have any questions, please ask me now or at any time they arise during the experiments. As a reminder, please do not communicate with any of the other participants during the experiment.
APPENDIX O

INSTRUCTIONS FOR CELL D

Instructions for all participants.

Please do not communicate with any of the other participants!

In this experiment, you will be the owner of a firm. Each firm in the experiment is identical, consists of one owner, produces an identical product, and has identical production costs. As the owner of your firm, you are responsible for deciding how many units of output your firm will produce.

There are two firms in each market, your firm and one other firm. At the beginning of the experiment, you will be paired with a firm selected at random from the other participants and will remain paired with that firm for the entire experiment. At the beginning of each period (round), each owner will simultaneously and privately pick output levels \( x \) for their firm. Once both owners have selected output levels, the market will purchase all production from both firms at the market clearing price \( P \), which is explained later in the instructions. The profits for each firm will then be calculated. As the owner you retain all of your firm's profits (revenue minus production cost). You will be compensated at the end of the experiment based on the total profit earned by your firm. The experiment will last for sixty (60) periods.

The market-clearing price is determined as follows:

\[
P = 120 - x_1 - x_2
\]

The minimum value for \( P \) is zero.

\( x_1 \) is the output level for your firm.

\( x_2 \) is the output level for the other firm.
The cost of production for each firm is 40. Each and every unit your firm produces, costs your firm 40. The profits for your firm are calculated as follows:

\[ \text{Profit} = P*x_1 - 40*x_1 \]

If the selling price \( P \) is less than 40, then no sales take place.

Example: Your firm produces 10 units and the rival firm produces 25 units. The market clearing price would be: \( P = 120 - 10 - 25 = 45 \). Since the market price is NOT less than 40, both firms produce their units and sell them to the market for 55 each.

The profit for your firm would be \( 55*10 - 40*10 = 600 \).

**Review of sequence of play**

1. Your firm is randomly paired with another firm at the beginning of the experiment.
2. Both owners simultaneously and privately select output levels.
3. The market clearing price is determined and the market purchases all output.
4. Both firms' profits are calculated for the current period.
5. If this is the sixtieth period the experiment ends, else go back to step 2.

At the end of the experiment you will receive cash. You will receive 1 cent per every 30 points earned, rounded to the nearest nickel. For example, if you accumulate 12030 points you get 12030/20 which is $4.01 rounded to the nearest nickel is $4.00.

If you have any questions, please ask me now or at any time they arise during the experiments. As a reminder, please do not communicate with any of the other participants during the experiment.
LIST OF REFERENCES


