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AN EMPIRICAL EVALUATION OF TWO JOINT COST ALLOCATION SCHEMES: A LABORATORY EXPERIMENT

The University of Oklahoma PH.D. 1983

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

AN EMPIRICAL EVALUATION OF TWO JOINT COST ALLOCATION SCHEMES: A LABORATORY EXPERIMENT

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BY

HAI GEUN PARK

Norman, Oklahoma

1983

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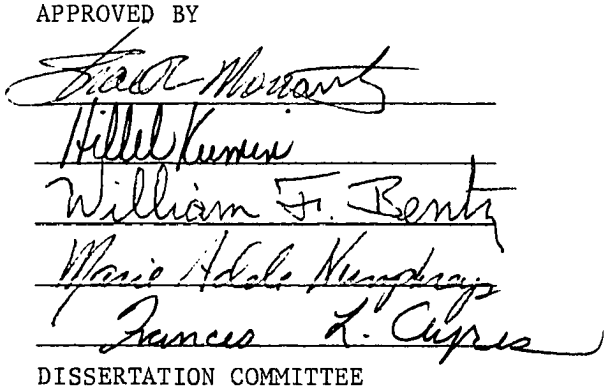
APPROVED BY



DISSERTATION COMMITTEE

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Joint cost allocation is a pervasive phenomenon in accounting practice. Under the generic name of "joint cost allocation" there are, in practice, several different joint cost contexts. For example, there are the allocation of fixed factory overhead and service department costs among production departments, the allocation of a joint input cost among products which are manufactured using a joint input, the allocation of joint facility costs among departments or divisions which use a common facility, and the allocation of a depreciable asset's service potential over its expected service life. This prevalence of joint cost allocation in accounting practice has captured the interest of accounting researchers and the topic of joint cost allocation has long been discussed in the accounting literature.

This project is a study intended to provide some empirical evidence on the relative usefulness of two joint cost allocation methods: the net realizable value and the Shapley value allocation schemes, in the context of a decision-making situation.

This chapter reviews the existing accounting literature concerning joint cost allocations, and describes the perceived need which led to the current research. Subsequent chapters will describe the research design adopted by this study, the statistical analyses of the results from the study, and the implications of the findings.

Literature Review

Dopuch (1981) has noted that the attitudes of accounting researchers regarding joint cost allocations appear to have changed over the years. Researchers have gone from complete acceptance of joint cost allocations to considerable doubts regarding the merits of joint cost allocations and now back to justifications and rationales for the existance of joint cost allocations. Thomas (1969, 1971, 1974, 1980) was a leader in the movement to rid the world of arbitrary and incorrigible cost allocations. He even suggested that major changes in accounting theory would be required to escape the allocation problem (Thomas, 1969, 1974). Kaplan (1977) also asserted that many accountants

and almost all economists argue that any allocation of joint costs is arbitrary and serves no useful purpose. Except for inventory valuation for financial and tax reporting, government contracting, rate setting, cost documentation for possible anti-trust suits (e.g., the Robinson-Patman Act), or cost-plus pricing, the accounting literature went through a period in which it generally recommends the avoidance of cost allocations (Zimmerman, 1979). However, it has recently become apparent that the normative arguments against cost allocations do not appear consistent with cost accounting practices. Believing that over time rational behavior prevails, accounting researchers now question this inconsistency between normative cost accounting theory and cost accounting practice. Some accounting scholars have noted possible benefits from the allocation of costs. Horngren (1977, p. 508), for example, concludes:

> In one organization, allocation may be desirable because it induces the desired behavior. In another organization, the same allocation procedure may cause an opposite behavioral effect.

As we see in the citation above, Horngren conjectures that managers behave differently if costs are allocated and that cost allocation is useful when it induces desirable managerial behavior. Zimmerman (1979) demonstrates that there are sound reasons for the practice of cost allocation by providing some concrete examples and sufficient conditions which support Horngren's conjecture. Zimmerman

argues that by charging for joint services a firm may reduce the slack in a manager's budget, leading to a reduction in discretionary consumption in other areas. Moriarity (1981, pp. 8-10) also suggests that usefulness for managerial decisions may be the ultimate rationale for allocations:

> . . . if we determine they (cost allocations) are useful, then the identification of what we are trying to accomplish may provide us with guidance on how we should go about allocating costs. . . .
> . . . It seems to me that a convincing rationale (for cost allocations) will need to state that allocations provide information useful for making managerial decisions. . . .
> . . . I believe if we are going to justify our effort, we must identify situations in which allocations are in fact useful for managerial decisions.

Moriarity suggests two situations in which cost allocations may be potentially beneficial to decision makers; one situation in which cost allocations will signal optimal capacity adjustments and another in which cost allocations will signal the relative profitability of products.

While relatively little work has been devoted to justifying allocations, there is a large literature devoted to methods of allocation. The majority of accountants who support allocation favor allocations in proportion to some measure of the relative revenue-generating power identifiable with individual products. The most popular measure that results in a cost indicative of revenue-generating power is some approximation of net realizable value. Net realizable value is commonly defined as the predicted selling price in the ordinary course of business

less reasonably predictable costs of completion and disposal. Thomas (1974, p. 44) maintains that the net realizable value allocation is sterilized with respect to further-processing decisions. He explains the sterilized character of the net realizable value allocation as follows:

> Further-processing decisions should be made by referring to the (unallocated) net realizable values of each product. But if one insists upon referring, instead, to allocated book gross profits, the allocations may be sterilized by making sure that they result in book gross profits that have the same algebraic signs as the related net realizable values (positive whenever the latter are positive, zero or negative otherwise).

Another approach to the question of how to allocate joint costs can be found in the area of game theory. Several game-theoretic schemes for allocating joint costs have recently been described in the accounting literature. They are generally applications of the Shapley (1953) value of a game to the allocation of joint costs in a multi-division firm. Essentially, what Shapley does is to define a unique division of joint rewards from a cooperative n-person game. The conceptual basis for Shapley's scheme is that participants in a game can improve their payoffs by entering into coalitions with other players. All possible coalitions are then considered, weighted by the likelihood they would be formed, in apportioning the joint rewards. In the cost allocation context, this approach determines the incremental costs to each user of a joint facility in such a way as to have the sum of those costs equal the full cost of

providing the common service. Given that increasing external cost economies are present, the result is that the charge (i.e., the allocated incremental cost) to users is less than the costs they would incur if they provided the service to themselves individually or as members of subcoalitions. Scholars call this result a "core solution" and they say that this allocation lies in the core. The special appeal of the Shapley scheme, as applied to the accountant's allocation problem, is that it provides for an equitable sharing of cost externalities arising from the jointness of production.

Shubik (1962) was the first to apply the Shapley scheme specifically to cost allocations. Using the Shapley axioms, he defined a sharing formula on the firm's profits, net of joint costs, and then used the resulting profit allocation to impute an allocation of joint costs.

Similar to Shubik, Loehman and Whinston (1971, 1974) used an axiomatic approach to derive an allocation of costs in a more decentralized setting. They differ from Shubik in that they defined their charge formula over incremental costs rather than over profits. They considered the problem of allocating a joint cost resulting from a group of collaborators agreeing to share a common facility, where each collaborator has a fixed positive demand. They proposed five axioms which supposedly characterize an equitable distribution of the joint cost. Acceptance of

these five axioms as an allocation constitution results in the definition of a unique allocation scheme known as the Shapley value.

Jensen (1977) examined the situation where users with fixed demands must share a joint facility's cost. If the users find the five Loehman-Whinston axioms mutually satisfactory, then the Shapley value will allocate the costs accordingly. Jensen also showed that the Shapley value satisfies the five advantages that Moriarity (1975) listed for his allocation scheme. Finally, Jensen presented some computationally simplified forms of the Shapley value for certain specialized joint cost allocation settings.

Hamlen, Hamlen, and Tschirhart (1977) used the criterion of neutrality to evaluate four allocation schemes. They argued that core allocation schemes are neutral and showed that the activity level scheme, the Shapley value, and the nucleolus scheme are core solutions in the context of a decreasing marginal cost function. They also showed that the Moriarity allocation scheme (1975) does not necessarily lie in the core and hence can lead to suboptimal solutions. Later, Hamlen et al. (1980) proposed the use of a generalized Shapley value which allows the correction of two possible weaknesses of the simple Shapley value. The first weakness they identified is that the simple Shapley value is a unique solution and does not allow the flexibility that management often needs. Secondly, there

are some situations in which the simple Shapley value does not lie in the core, even when it is in the best interests of the firm for all parties concerned to cooperate.

Callen (1978) argued that financial cost allocations can be rendered nonarbitrary by acceptance of a constitution of axioms which lead to the Shapley value. He viewed "players" as assets and coalitions as firms. Given this definition, and acceptance by financial statement users and accountants of the aforementioned constitution, then a unique, defensible, nonarbitrary allocation of depreciation results.

Roth and Verrecchia (1979) suggested that the Shapley value may be viewed as a costless surrogate for the bargaining process. That is, firms could allow managers of subunits to meet and bargain among themselves in order to determine the amount of services to provide and how the costs should be shared. Avoidance of the cost of this negotiation process may be why firms establish mutually satisfactory allocation schemes. They proved a theorem which states that the Shapley value is the certainty equivalent of the bargaining process if, and only if, managers display ordinary risk neutrality and strategic risk neutrality (i.e., they perceive themselves as having equal bargaining positions). In effect, given the two assumptions, managers would be indifferent between receiving the Shapley value and bargaining to receive an uncertain

allocation.

Verrecchia (1982) presented a possible practical application of the Shapley value. The setting examined is concerned with an allocation of corporate state and local income and franchise taxes in a manner mutually agreeable to a large defense contractor and the U.S. government. Each party was suggesting an allocation scheme favorable to themselves and unfavorable to the other. Verrecchia advocated the use of the Shapley value to resolve the dispute citing the equity properties of the method.

While the Shapley value has many proponents, it also has detractors. Thomas (1980) compared the Shapley value with a specially concocted allocation scheme in a joint cost setting. The comparison was based on multiple criteria extracted from the accounting literature. The criteria correspond to certain desirable operating properties of an allocation scheme. Based on his analysis, he concluded that the specially concocted allocation scheme is superior to the Shapley value. And, since the special allocation scheme was constructed to be deliberately absurd, he stated that accounting researchers may have been overly enthusiastic for Shapley allocations.

Hughes and Scheiner (1980) assumed that the users of a joint facility are divisions. They further assumed that the demands of the users are not fixed. Then, in a two-divisional setting, they proceeded to demonstrate that

the Shapley allocation of a common cost will not be neutral, i.e., suboptimal actions will be taken by the divisions. They also demonstrated that any full cost allocation scheme would lead to suboptimal behavior. They concluded that the core criterion for an allocation scheme is not a sufficient condition for neutrality.

It is on the basis of equity that the Shapley value derives its main appeal. Thomas (1980), however, rejects the notion of equity as a sufficient condition for a justifiable allocation scheme. He has argued that even though individuals affected by a joint cost allocation may agree that the Shapley axioms are equitable in nature, they may be dissatisfied when the actual allocation is received. Joint users often have conflicting interests and they may implicitly feel that they could have done better if they had been allowed to pursue their own interests, e.g., through a bargaining process. While Roth and Verrecchia (1979) showed that strategic risk neutrality leads to the Shapley value being the certainty equivalent of the bargaining process, it is doubtful that many allocation settings would find players viewing themselves as having equal bargaining positions. Consequently, in most situations players would not be willing to accept the Shapley value in lieu of negotiating a mutually acceptable allocation. In this situation it appears necessary for players to negotiate the share of the payoff to be earned from the jointness.

There are a number of social psychological models of coalition behavior which seem relevant to the allocation problem. These models predict how coalitions will form and, additionally, predict how the payoffs will be distributed among the players in the coalition. The term coalition may be defined as the joint use of resources to determine the outcome of a decision in a mixed-motive situation involving two or more individuals (Gamson, 1964). Gamson (1964, p. 85) explains the mixed-motive situation:

> . . . each participant wishes to maximize his or her relative influence over the outcome of the decision. Since this can only be done at the expense of others, the reconciliation of disagreements could be considered a mixed-motive situation.

Two social psychological models of coalition formation seem to be particularly important in the problem of joint cost allocation: minimum resource theory and bargaining theory.

Minimum resource theory emphasizes the initial resources which the players bring to the situation rather than their strategic bargaining position. Gamson (1961) made the connection between the relative strength of members of a coalition and the distribution of rewards more explicit. He suggested that "any participant will expect others to demand from a coalition a share of the payoff proportional to the amount of resources which they contribute to a coalition." Gamson (1964, p. 88) also states:

> This (The parity norm) is the belief by the participants that a person ought to get from an agreement an amount proportional to what he brings into it. It is important to note that this is not an assessment of relative power in the situation, but a statement of what the players feel they deserve. It is a normative belief, not a perception of bargaining advantage.

Boatsman, Hansen, and Kimbrell (1981) proposed a minimum resource allocation scheme as an alternative to the Shapley value allocation. Their consideration is that an allocation scheme must be equitable in the sense that it reflects the relative needs or relative contributions of the individual recipients. They maintained that the minimum resource allocation scheme is essentially equivalent to the widely used activity level allocation scheme and that it is a suitable surrogate for the bargaining process. They empirically investigated how the ownership of merged firms are divided between the shareholders of the acquiring and acquired firms. Their empirical test provided some evidence which suggests that the minimum resource allocation scheme describes the behavior of real world negotiants.

Bargaining theory (Komorita and Chertkoff, 1973) assumes that the division of the payoff within a coalition will be a compromise between two conflicting norms. A coalition member who is weak in resources will advocate that the payoff be divided according to a norm of equality, that is, the payoff should be divided equally, while a member who is strong in resources will argue for a division of the payoff according to the parity norm. In fact, the

prediction for the initial trial is that the players will expect their rewards to be midway between the predictions of the parity norm and those of the equality norm.

The major difference among the Shapley value allocation, the minimum resource allocation, and the bargaining theory allocation is in their division of the payoff within a coalition. The Shapley value allocation divides the payoff equally based on the assumption that players have equal bargaining positions (the equality norm). The minimum resource allocation distributes the payoff in proportion to the amount of resources which players contribute to a coalition (the parity norm). The bargaining theory allocation divides the payoff based on a compromise between the two conflicting norms. That is, the players' rewards are midway between the predictions of the parity norm and those of the equality norm.

There is another allocation scheme similar to the minimum resource allocation scheme. Moriarity (1975) suggested an allocation scheme which divides the payoff in proportion to independent costs (i.e., the costs of obtaining services independently). It was observed that this allocation basis does not require any additional data beyond that necessary to calculate the cost savings to a coalition and also that it allocates in a manner that does not possess several dysfunctional aspects of the then existing allocation procedures.

Gangolly (1981) has developed an alternative scheme for the allocation of joint costs which uses the same equity principle as the Moriarity scheme, that is, sharing of cost savings in proportion to independent costs. He proposed the "Independent Cost Proportional Scheme (ICPS)" which yields core allocations when there are three or more cost centers and the marginal costs are nonincreasing. The ICPS thus preserves both core membership and Moriarity's principle of proportional equity. The ICPS satisfies substantially the same properties as the Shapley value allocation scheme except for "invariance under strategic equivalence." Since the ICPS is not invariant, it depends in a crucial manner on the aggregation of costs by an accounting system.

As this review indicates, the accounting literature contains various arguments claiming that some allocation procedures are, in some sense, better than others. Various schemes have been both supported and questioned. However, the arguments are normative in nature and there is virtually no empirical work to evaluate the competing allocation schemes. The present study was undertaken in an attempt to empirically evaluate two of the normative allocation schemes which have been proposed.

The Need For This Research

Because accounting is a pragmatic discipline, it can be justified only in terms of its usefulness in the real

world. Therefore, various accounting concepts and procedures must relate to real world phenomena and behavior. This relationship between real world phenomena, behavior and various accounting concepts and procedures can only be determined by empirical research. The 1972 AAA Committee on Research Methodology in Accounting (1972, pp. 440-441) addresses the importance of empirical studies as follows:

> Empirical studies that are well designed to test limited and clearly stated hypotheses should facilitate and encourage additional studies to substantiate as well as build on the earlier work. It is reasonable to anticipate that this approach will enable accounting research to progress slowly but surely in the direction of developing and testing an increasing range of hypotheses. Verified (or rejected) hypotheses should, in turn, provide the basis for validating theoretical statements concerning the nature and consequences of various accounting practices. . . .
> . . . Thus, each properly conducted and properly reported investigation, as well as each effort to reconcile conflicting findings, make an incremental contribution to the development of a solid body of knowledge about accounting.

In line with the developing emphasis on empirical research, this study tries to provide some empirical evidence on the relative usefulness of the net realizable value and the Shapley value allocation methods. The long-run intent is to help resolve the conflicting normative arguments being made about those procedures.

Purpose Of The Study

Among the various allocation procedures reviewed, the net realizable value and the Shapley value allocations appear to have been the most widely discussed in accounting

text books and in the accounting literature. The net realizable value allocation scheme has been the most popular method of allocating joint costs in accounting text books. Thomas (1974, p. 168) addresses some advantages of the net realizable value approach. He maintains that the net realizable value approach is mechanically simple and it is fair in the sense that it allocates joint costs in proportion to each product's ability to bear the costs. He also maintains that it does not affect further-processing decisions. In the recent accounting literature, however, a game-theoretic approach, specifically the Shapley value allocation scheme, has earned popularity among several accounting scholars. These accounting researchers find the special appeal of the Shapley value allocation scheme to be that it lies in the core and it provides for an equitable sharing of cost externalities arising from the jointness of production.

In reviewing these two schemes a question naturally arises: Which allocation procedure (the net realizable value or the Shapley value allocation) is "better"? In order to answer this question we must operationalize the criteria "better". In the belief that the ultimate rationale for cost allocations may be their usefulness for managerial decisions, the two allocation schemes were compared in a specific decision situation.

A second criterion for the term better was

developed from Jensen's work. As stated earlier, there are several different situations in which joint costs are allocated. This study will focus on a situation in which a joint facility is used by decentralized divisions. In that situation mutually satisfactory allocations are agreements among collaborators to share the joint facility cost (Jensen, 1977; Thomas, 1971, 1974). Such agreements may be negotiated by collaborators with the assistance of accountants and other outsiders. Jensen (1977), for example, suggested that accountants may assist the negotiation of cost-sharing arrangements by providing formulas that possess characteristics desired by the collaborators. Jensen views the accountants' role as varying according to the degree to which formulas displace the bargaining behavior of collaborators. In some cases, accountants are completely absent from the negotiation process and mutually satisfactory allocations are strictly the outcome of bargaining among the collaborators. In other cases, accountants may be impowered to impose an allocation result and users of the joint facility are compelled to accept it. Jensen called this allocation an "imposed allocation" (Jensen, 1980). Imposed allocations are often recommended based on the consideration that they may increase the benefits to collaborators by avoiding costly negotiations and by securing an optimal use of facilities that negotiators may be unable to reach.

The purpose of this study is to provide some empirical evidence on the relative usefulness of two imposed allocation schemes by empirically evaluating the two allocation schemes with regard to: (1) their effects on divisional managers' pricing decisions and therefore on divisional profits and a firm's overall profit, and (2) their effects on divisional managers' perceived fairness of the cost allocations and on their decision of whether they wish to collaborate in using the joint facility.

Design Of The Study

This study uses a laboratory experiment simulating the pricing decision for two divisional managers. The two managers (the Division 1 manager and the Division 2 manager) operate in independent markets but use a common resource. The experiment is intended to demonstrate whether different allocation procedures lead to different operating decisions.

Summary

This chapter has reviewed the current literature on joint cost allocations and described the value which an empirical study might provide to help resolve the conflicting normative arguments about joint cost allocation procedures. The next chapter examines some alternative approaches which might have been taken and summarizes the reasons why an experimental approach was chosen.

CHAPTER II

RESEARCH METHODOLOGY

Introduction

The 1973 AAA Committee on Internal Measurement and Reporting (1973, pp. 215-216) describes several difficulties in choosing between the methods available for testing hypotheses in the area of internal measurement and reporting as follows:

> First, the 1970-71 AAA Committee on Research Methodology in Accounting came to the conclusion that "the methods appropriate for research in accounting can be stated quite simply: All methods are appropriate." As a result, no list of appropriate accounting research methods was forthcoming. Instead, each committee member wrote on a research method reflecting his interests and beliefs in the importance of the topic. No effort was made to compile an exhaustive list of methods.
>
> Second, the appropriateness of a research method cannot be evaluated without placing it within the context of the research question. . . . Although specific context is necessary for evaluation of a particular research method, knowledge of the general field of inquiry should be sufficient for identification of potential research methods.
>
> Third, before a list of methods can be prepared, some definitional groundwork must be done to delineate what is meant by various terms. Do methods include only those techniques for gathering data? Is data analysis a research method? Or does a research method encompass the entire research framework from having an idea to final data analysis?

This study defines research methodology narrowly as the methods for gathering data.

Alternative Methodologies

The 1973 AAA Committee on Internal Measurement and Reporting (1973, pp. 219-225) has divided methodologies into three basic areas: Historical, Experimental, and Field Study approach. The following is an examination on some of the major advantages (strengths) and disadvantages (weaknesses) of the research methodologies based on the Committee report.

Historical Approach

The historical approach relies primarily on document examination. Document examination includes the gathering of data from libraries, financial statements, company records, data banks, etc.

The major advantages of this approach include:

(1) Document examination is relatively cheaper than setting up and completing an experiment or a field study.

(2) A change in events over time can be studied retrospectively.

The major disadvantages of this approach include:

(1) Previously documented events have been subjected to at least one "filter" by the original observer.

(2) Data may not exist which allows the study of the

research problem.

(3) Data must be accepted as is and may not allow additional "in-depth" examination.

Experimental Approach

Experimental data are generated when the researcher designs a controlled situation to test a specific hypothesis, manipulates at least one of the variables, and measures the reaction of the uncontrolled (dependent) variables. The experimental approach can be further divided into three areas: laboratory, field, and simulation methods.

Laboratory experiment. The laboratory experimental design generally attempts to control or keep the variance of all or nearly all of the possible influential independent variables not pertinent to the problem at a minimum.

The major advantages of this approach include:

(1) The laboratory environment facilitates control of the variables by eliminating extraneous and, perhaps, otherwise uncontrollable influences.

(2) It allows manipulation of variables.

(3) Random assignment is possible allowing statistical inference.

(4) Relatively precise observations or measurements are possible.

The major disadvantages of this approach include:

(1) Because of the artificial nature of the laboratory situation subjects' motivations may be different from those encountered in real situations.
(2) It is usually difficult to generalize the results. That is, the results may not extrapolate beyond the laboratory.
(3) It is usually difficult to design a good experiment.

Field experiment. Field experiments include those research studies conducted in a field setting in which one or more independent variables are manipulated by the experimenter under as carefully controlled conditions as the situation will permit.

The major advantages of this approach include:

(1) It allows manipulation of variables.
(2) Random assignment is possible allowing statistical inference.
(3) Since it is conducted in a lifelike setting variables usually have greater realism than in a laboratory situation.

The major disadvantages of this approach include:

(1) The researcher may not be able to manipulate important variables due to practical constraints.
(2) In a lifelike setting it may be difficult to assign subjects randomly to treatments.

(3) The research may need to be justified to the people being examined, thus losing the objectivity of the participants.

Simulation. Simulation involves the creation of an operating model of a system (persons, firms, or economies) and experimenting on this representation by manipulating its variables and their interrelationships. Developing the model used in the simulation involves the isolation of those variables in the system which are hypothesized as pertinent to the problem.

The major advantages of this approach include:

(1) It allows the study of complex internal interactions of a system.

(2) It allows experimentation with new situations about which we have little or no information.

(3) It allows examination and prediction in those situations which are infeasible or too costly to examine otherwise.

(4) It allows sensitivity analysis of the system.

The major disadvantages of this approach include:

(1) All aspects of the system must be rigorously specified prior to creation of the model to avoid subsequent costly revisions.

(2) Validation of model parameters may be difficult or impossible. This leads to results which are

suspect.

(3) The technique may not be easily interpreted or understood by many of the people using the results.

Field Study Approach

A field study involves "ex post facto" scientific inquiries aimed at discovering the relations and interactions of variables in real situations. Field studies may be either exploratory, trying to discover "what is," or hypothesis testing, trying to predict relationships.

The major advantages of this approach include:

(1) Since field studies are conducted in a more realistic environment, external validity and the practical significance of the results are high (Abdel-Khalik and Ajinkya, 1979, p. 45).

(2) A large number of variables and their interactions in a complex setting can be investigated.

The major disadvantages of this approach include:

(1) Control is difficult and variables cannot be manipulated.

(2) The low level of control makes it very difficult to draw causal inferences (Abdel-Khalik and Ajinkya, 1979, p. 45).

(3) It usually takes a relatively large amount of time and money to collect the data.

Laboratory Experiment For The Study

This study intends to empirically evaluate the net realizable value allocation and the Shapley value allocation methods in a decision situation. Since there is no available information about the effect of different cost allocation methods on managers' decisions, a historical approach cannot be used. There are two alternative approaches remaining. One is an experimental approach and the other is a field study approach. This study did not adopt a field study approach because it seemed unlikely that a sufficient number of appropriate real situations could be formed. That is, it would be necessary to locate several situations in which two divisional managers use a common facility and the joint cost in some cases is divided based on the net realizable value allocation method while in others the Shapley value allocation method is used. Thus, an experimental approach seemed to be the only viable methodology left for this study.

As stated earlier, there are three different methods in an experimental approach; using a laboratory experiment, a field experiment, or simulation. The simulation method was not adopted in this study because it seemed important that hypotheses concerning the activities of individuals should be tested by analyzing the behavior of real-life subjects. Moreover, even sophisticated simulation techniques cannot completely capture all of the factors that

encompass the decision process of actual decision makers. Because the simulator, or researcher, may overlook some factors, the simulations must also be tested against the actions of real decision makers. Consequently, the ultimate test of hypothesized behavior is observed behavior.

The remaining alternatives are a laboratory experiment and a field experiment. This study did not select a field experiment because it is too costly and difficult to construct a field setting. Therefore, a laboratory experiment was adopted in this study.

Summary

This chapter has defined research methodology as a method for gathering data. It described several alternative methodologies with their strengths and weaknesses. Then, the reason why this study adopted a laboratory experiment as its methodology was stated.

CHAPTER III

RESEARCH DESIGN AND PROCEDURE

Introduction

This chapter presents the specific questions addressed in this study. The questions are addressed in terms of the null hypotheses to be tested. Then, the decision situation chosen for this study is described. Based on the setting a series of experiments were designed and conducted to generate the data that will be used in testing the hypotheses. Finally, the statistical techniques used in this study to analyze the data obtained from the experiment are explained.

Research Questions And Hypotheses

As stated in Chapter I, this study intends to provide some empirical evidence on the relative usefulness of the net realizable value and the Shapley value allocation schemes by empirically evaluating the two schemes in a two-divisional pricing decision situation. A pricing decision situation was chosen to evaluate the two schemes because

cost-based pricing is one of the major uses of allocations. Allocations for cost-based pricing are frequently made in practice according to a recent study by Fremgen and Liao (1981, pp. 64-66). Their study shows that 66 out of the 108 companies that responded to their survey were allocating corporate common costs for purposes of setting cost-based prices. In order to evaluate the two allocation schemes, this study addresses the following questions:

(Research question 1)

Do the two allocation schemes affect divisional managers' pricing decisions differently and therefore render different divisional and overall net incomes (in this study "overall net income" is defined as the sum of the two divisional net incomes)? If they do, which allocation scheme leads to prices that render net incomes closer to the optimal net incomes?

(Research question 2)

Do the two allocation schemes differ in their effect on the divisional managers' ability to adjust prices when demand changes? If they do, which allocation scheme allows them to approach optimal prices more closely?

(Research question 3)

Do the two allocation schemes differ in terms of their perceived fairness in the division of joint cost? If they

do, which allocation scheme do divisional managers feel is more fair?

(Research question 4)

Do the two allocation schemes differ in encouraging divisional managers to cooperate in using the joint facility? If they do, which allocation scheme encourages cooperation more?

These questions will be addressed in terms of the following null hypotheses to be tested in a two-divisional setting.

(Hypotheses for research question 1)

H(1): There is no significant difference in the pricing performance of the Division 1 managers under the two allocation schemes.

H(2): There is no significant difference in the pricing performance of the Division 2 managers under the two allocation schemes.

H(3): There is no significant difference in the overall net incomes reached by the participants using the two allocation schemes.

(Hypotheses for research question 2)

H(4): There is no significant difference in the pricing performance of the Division 1 managers under the two allocation schemes when the market demand

function changes.

H(5): There is no significant difference in the pricing performance of the Division 2 managers under the two allocation schemes when the market demand function changes.

H(6): There is no significant difference in the overall net incomes reached by the participants under the two allocation schemes when the market demand function changes.

(Hypotheses for research question 3)

H(7): There is no significant difference in the managers' combined perceived level of fairness concerning the allocation of the joint cost under the two allocation schemes.

H(8): There is no significant difference in the level of disparity in the fairness perception between the divisional managers concerning the allocation of the joint cost under the two allocation schemes.

(Hypothesis for research question 4)

H(9): There is no significant difference in the proportion of managers desiring to continue the use of the joint facility under the two allocation schemes.

The Experimental Setting

In order to evaluate the two joint cost allocation schemes a specific situation which is appropriate for the evaluation was needed. The hypothetical situation chosen is a copy shop. A copy shop was chosen in part because it involves a relatively simple situation. That is, a copy shop performs copying service upon receiving customers' orders and as a result, it does not have significant inventories of product during the accounting period. In addition, the major cost of operating such a shop is the rental of the copier. Further, real data on copier rentals was readily available from the manufacturers which allowed me to build some external validity into the situation. Finally, choosing a copy shop also provides the advantage that the subjects (students) should be fairly familiar with the workings of a copy shop.

The manager of each copy shop was given the objective of maximizing immediate, short-run profit. The business consists of two divisions.*
Divisional managers were given profit responsibility; that is, they were told that they would be evaluated on the basis of the amount of profit their division earned during an accounting period. Therefore, the managers should desire to maximize their divisions' immediate, short-run profits.

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*The term "profit center" would be more appropriate, but it was felt that the experimental subjects would better understand the term "division."

Managers were given the autonomy to set their own selling price. The price, in turn, was used along with a demand function to determine the amount of copying services performed. Income statements were prepared at the end of each period. It was assumed that the market was clearly segmented for the two divisions. Due to this market segmentation, divisional managers did not compete against each other for customers.

Each division's net income was calculated by subtracting its total cost from total revenue during a period. Total revenue was the product of the selling price and the quantity sold. The quantity sold was a function only of the selling price. Algebraically this relationship can be presented by a demand function $X = f(P)$, where X is the quantity sold and P is the selling price. In the experiment, each division faced two different demand situations (functions). That is, one demand function held for Periods 1-13 for each division and the demand function changed at the end of Period 13 into a different demand function for Periods 14-19 for each division. Specifically, Division 1 faced a demand function $X = 170/P^{2.5}$ for Periods 1-13 and a changed demand function $X = 16/P^{3.3}$ for Periods 14-19, whereas Division 2 encountered a demand function $X = 500/P^{2.2}$ for Periods 1-13 and a changed demand function $X = 1625/P^{1.8}$ for Periods 14-19. Demand functions for the two divisions are shown in table 1 as follows:

TABLE 1

DEMAND FUNCTIONS (DETERMINISTIC)

	Periods 1-13	Periods 14-19
Division 1	$X=170/P^{2.5}$	$X=16/P^{3.3}$
Division 2	$X=500/P^{2.2}$	$X=1625/P^{1.8}$

These demand functions were arbitrarily selected, but they were constructed to yield the following characteristics. First, the demand functions should be continuous functions of the selling price and they should not exhibit breaks or kinks in response to small alterations in the selling price. Instead, I wanted the response to small changes in the selling price to be smooth and continuous. Second, they should present a reasonable economic relationship between price and quantity. That is, demand should increase when price falls, whereas demand should decrease when the price becomes higher. Finally, they should be fairly realistic for a copy shop business. For example, the selling price and the quantity sold as determined by the functions should approximately reflect a reasonable copy shop operation.

In the hypothetical situation the total cost of each division was determined by the quantity of copies sold and the prices of the inputs hired. For simplicity, I assumed that each division's costs consisted of only the salary for one employee, the rent on the shop, and the use

of utilities (mainly electricity). In addition to these input factors, it was assumed that each manager rented a different copier. In particular, the copier used by Division 2 is of a more advanced model than that used in Division 1.

During the experiment at Period 9, central management (the experimenter) told the two managers to jointly use a copier which is more advanced and bigger than the two copiers they were using independently. The two managers were told that the use of the common copier would result in lower costs.

Table 2 shows the two divisions' cost functions in the case where they each rent and use a separate copier. When they rent and use a copier jointly, the costs would appear as shown in table 3. These cost functions were constructed based on both some real data and some assumed data. That is, the copier rental costs were the real costs available from the Xerox Corporation during the fall of 1982, but the other cost items were arbitrarily selected. The amounts were chosen in an attempt to be representative of a copy shop business and to maintain linear cost functions to make the problem simple. The cost functions shown in tables 2 and 3 remained unchanged throughout the experiment.

Given the demand functions (on page 33) and the cost functions (on pages 35-36), it is possible to calculate

TABLE 2

COST FUNCTIONS
(INDEPENDENT USE OF THE COPIER)

	Division 1		Division 2	
Copier rental	Quantity sold	Rental cost ($)	Quantity sold	Rental cost ($)
	$0 < X_1 \leq 100{,}000$	2,015	$0 < X_2 \leq 300{,}000$	3,885
	$100{,}000 < X_1 \leq 250{,}000$	$2{,}015+(X_1-100{,}000)\times.0092$	$300{,}000 < X_2 \leq 500{,}000$	$3{,}885+(X_2-300{,}000)\times.0087$
	$250{,}000 < X_1$	$2{,}015+(150{,}000)\times.0092+(X_1-250{,}000)\times.0084$	$500{,}000 < X_2$	$3{,}885+(200{,}000)\times.0087+(X_2-500{,}000)\times.0060$
Shop rental	$ 500		$ 600	
Salary	$ 600		$ 700	
Utilities	$ 300		$ 400	
Materials	$ .0306 X_1		$ .0306 X_2	

Note: X_1 and X_2 show the quantity sold in number of copies for Division 1 and Division 2 respectively.

TABLE 3

COST FUNCTIONS
(JOINT USE OF THE COPIER)

	Joint cost	
Joint copier rental	Quantity sold	Joint rental cost ($)
	$0 < X \leq 300,000$	5,600
	$300,000 < X \leq 700,000$	$5,600+(X-300,000) \times .0080$
	$700,000 < X$	$5,600+(400,000) \times .0080+(X-700,000) \times .0040$

	Independent cost	
	Division 1	Division 2
Shop rental	$ 500	$ 600
Salary	$ 600	$ 700
Utilities	$ 300	$ 400
Materials	$ .0306 X	$ .0306 X

Note: X represents total quantity sold in number of copies for Division 1 and Division 2 combined, i.e., $X = X_1 + X_2$.

the optimal price and net income using the traditional microeconomic profit maximization model by equating marginal revenue and marginal cost. The optimal prices and net incomes are calculated in Appendix A. The optimal values computed appear in table 4.

TABLE 4

THE OPTIMAL PRICES AND NET INCOMES (DETERMINISTIC)

		Periods 1-8	Periods 9-13	Periods 14-19
Division 1	Price	$ .066333	$ .064333	$ .055383
	Net income	$1,485.25	N:$1,381.30* S:$1,786.81*	N:$1,177.55* S:$1,497.48*
Division 2	Price	$ .0561	$ .070767	$ .08685
	Net income	$1,622.62	N:$1,940.42* S:$1,534.91*	N:$2,664.40* S:$2,344.47*
Overall net income		$3,107.87	$3,321.72	$3,841.95

* The optimal net income for each division will vary depending on how the joint cost is allocated between the two divisions. N stands for the net realizable value allocation and S, for the Shapley value allocation.

The optimal values presented in table 4 are based on deterministic demand and cost functions. In the demand functions (on page 33) the quantity sold (X) is a deterministic function of the selling price (P). In reality, however, the quantity sold cannot be predicted with certainty. Instead there will be some fluctuation in

demand. I constructed probabilistic demand functions for this study because they are realistic and they also prevent the experimental task from being a trivial exercise for the subjects.

In order to construct the probabilistic demand function I added a normally distributed error term with a zero mean value to the deterministic demand function. The revised demand function then is $X = f(P) + E$, where E is a normally distributed random number. In this function E shows the extent of random fluctuation around f(P) and therefore, E could be shown as a percentage of f(P). Denoting M as the mean, S as the standard deviation, and R as the normalized value, respectively of E, E can be presented as follows:

$E = R \times S \quad (\because R = (E - M)/S \text{ and } M = 0)$

Thus, S could also be shown as a percentage of f(P), i.e., $S = c \times f(P)$, where c is a coefficient showing the percentage. Then, the revised probabilistic demand function can be presented as follows:

$X = f(P) + R \times c \times f(P)$

In order to determine the probabilistic demand function the level of c had to be determined. In the probabilistic demand function two identical selling prices could be associated with different values for the quantity sold and, as a result, different values for net income. In this situation there is a probability that a divisional manager

making a pricing decision revises a prior price in the wrong direction. In other words, the random fluctuation distorts the manager's prediction and consequently it might lead the manager to an erroneous decision. If the extent of distortion is designated too high, the random factor will overshadow the pricing effect on net income. On the other hand, if the extent of distortion is designated too low, the random factor is virtually ignored and the managers' search for the optimal price will be too simple and trivial.

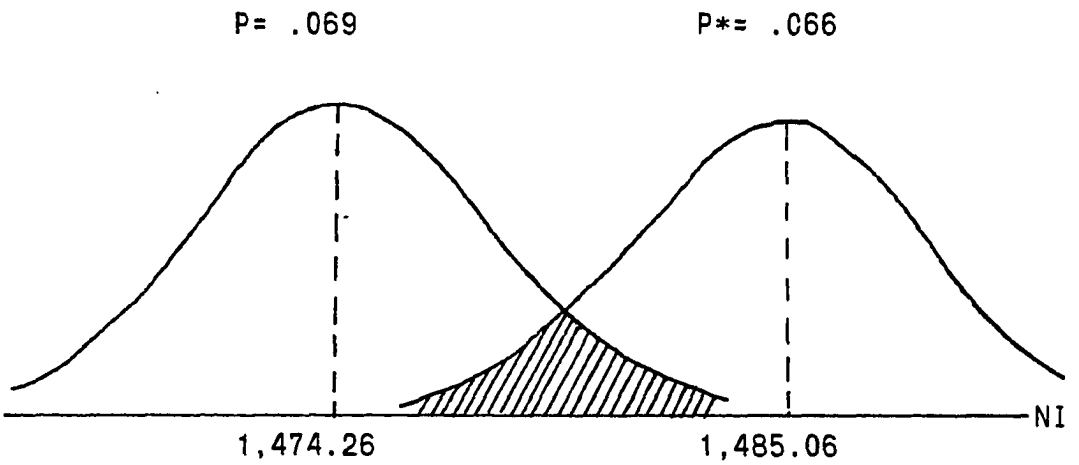
In order to determine the level of c, 1,000 pairs of net incomes were calculated (each pair consisted of two net incomes; one was a net income yielded by a quantity demanded at the optimal price and the other was a net income rendered by a quantity demanded at a price close to the optimal price). Then, the two net incomes in each pair were compared. This procedure was continued with different levels of c until about 100 pairs (10%) of the pairs yielded a net income associated with the optimal price which was smaller than the other net income.

In figure 1, with a normally distributed random factor, the divisional manager would obtain a different net income each time he or she sets the identical price, $ .066. The different net incomes determined by the price, $ .066 forms a normal distribution. In the same manner the different net incomes determined by the price, $ .069 forms the other normal distribution. The mean values (i.e.,

$1,485.06 and $1,474.26) were chosen such that the difference between the two net incomes was approximately ten dollars.

FIGURE 1

TWO NORMAL DISTRIBUTIONS



where P*= the optimal price
P = a price close to the optimal price
NI= net incomes

In figure 1, if the two distributions overlap, there is a chance that a net income associated with the price, $ .066 becomes smaller than a net income associated with the price, $ .069. Therefore, the overlapping area (shaded area in figure 1) indicates the probability that a manager will make an erroneous pricing decision due to the random factor. The procedure which was used to generate the random factor was intended to keep these erroneous decisions to approximately 10% of the decisions. The probabilistic

demand functions generated are given in table 5.

TABLE 5

DEMAND FUNCTIONS (PROBABILISTIC)

	Periods 1-13	Periods 14-19
Division 1	$X=170/P^{2.5}+R(.00137)(170/P^{2.5})$	$X=16/P^{3.3}+R(.00210)(16/P^{3.3})$
Division 2	$X=500/P^{2.2}+R(.00075)(500/P^{2.2})$	$X=1625/P^{1.8}+R(.00076)(1625/P^{1.8})$

Note: R represents the normalized value of the random number (E) with mean of zero and standard deviation of one.

The probabilistic demand functions in table 5, the cost functions in tables 2 and 3, and the resulting relations between net income and the selling price are presented graphically in figures 2, 3, 4, and 5.

The Experiment

Using the setting described in the previous section, a total of 60 experiments were conducted sequentially to generate the data to be used for testing the research hypotheses.

Each experiment involved the experimenter and a pair of subjects; one subject acting as the Division 1 manager and the other subject acting as the Division 2 manager. Each pair of subjects was scheduled to perform the experiment at a specific time. The first 30 experiments

FIGURE 2

DEMAND FUNCTIONS (PROBABILISTIC)

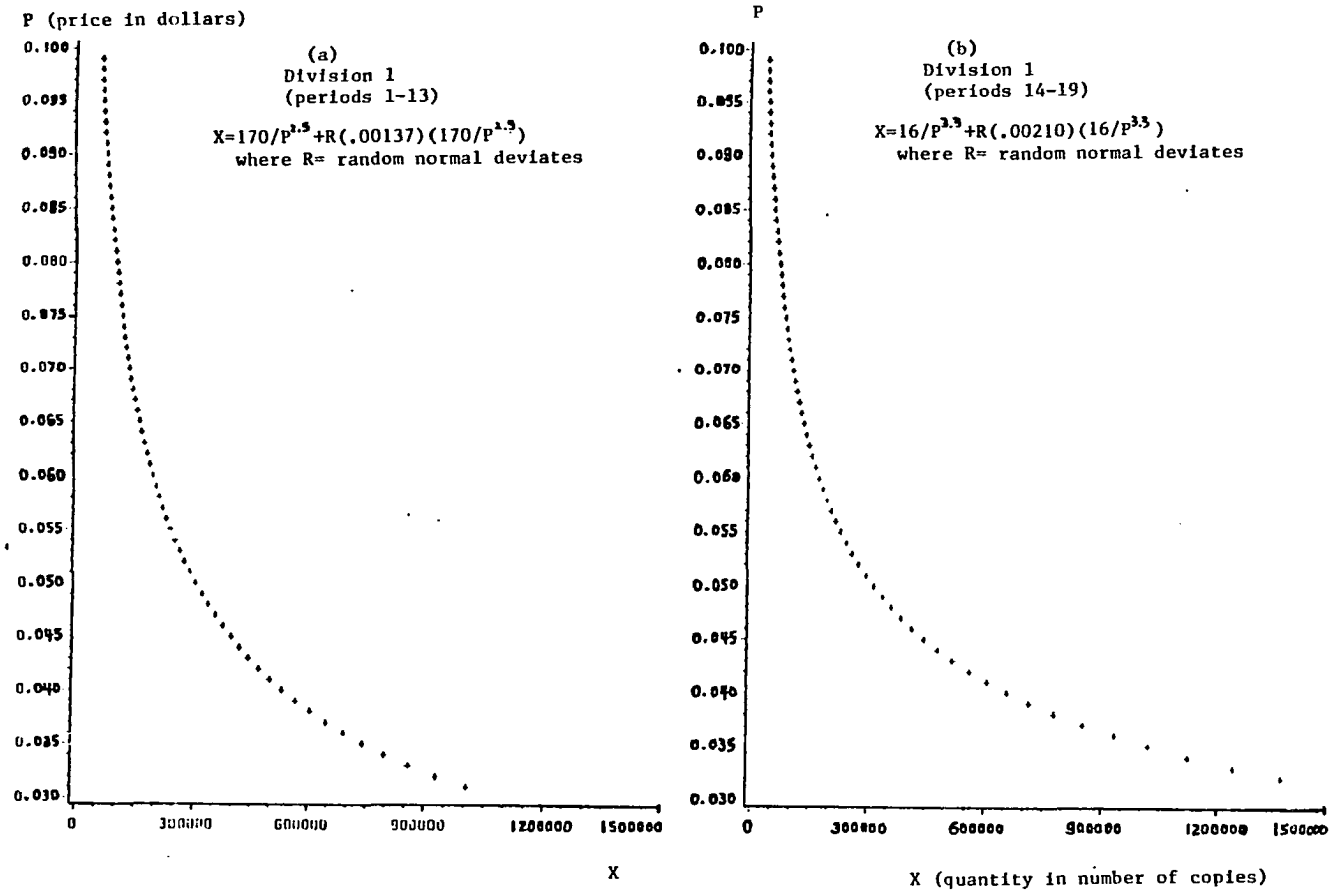


FIGURE 2 (CONTINUED)

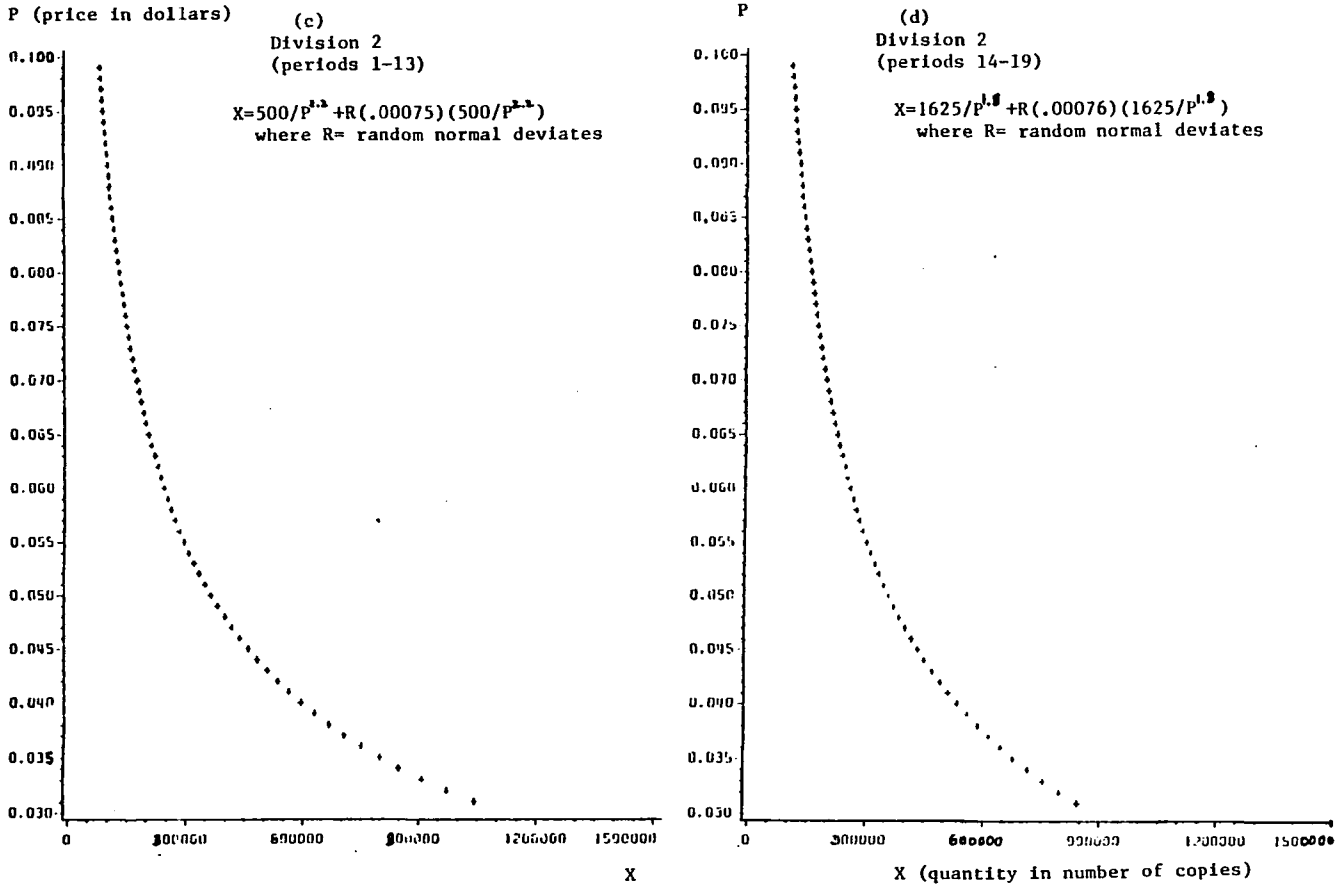


FIGURE 3

COST FUNCTIONS (INDEPENDENT USE OF THE COPIER)

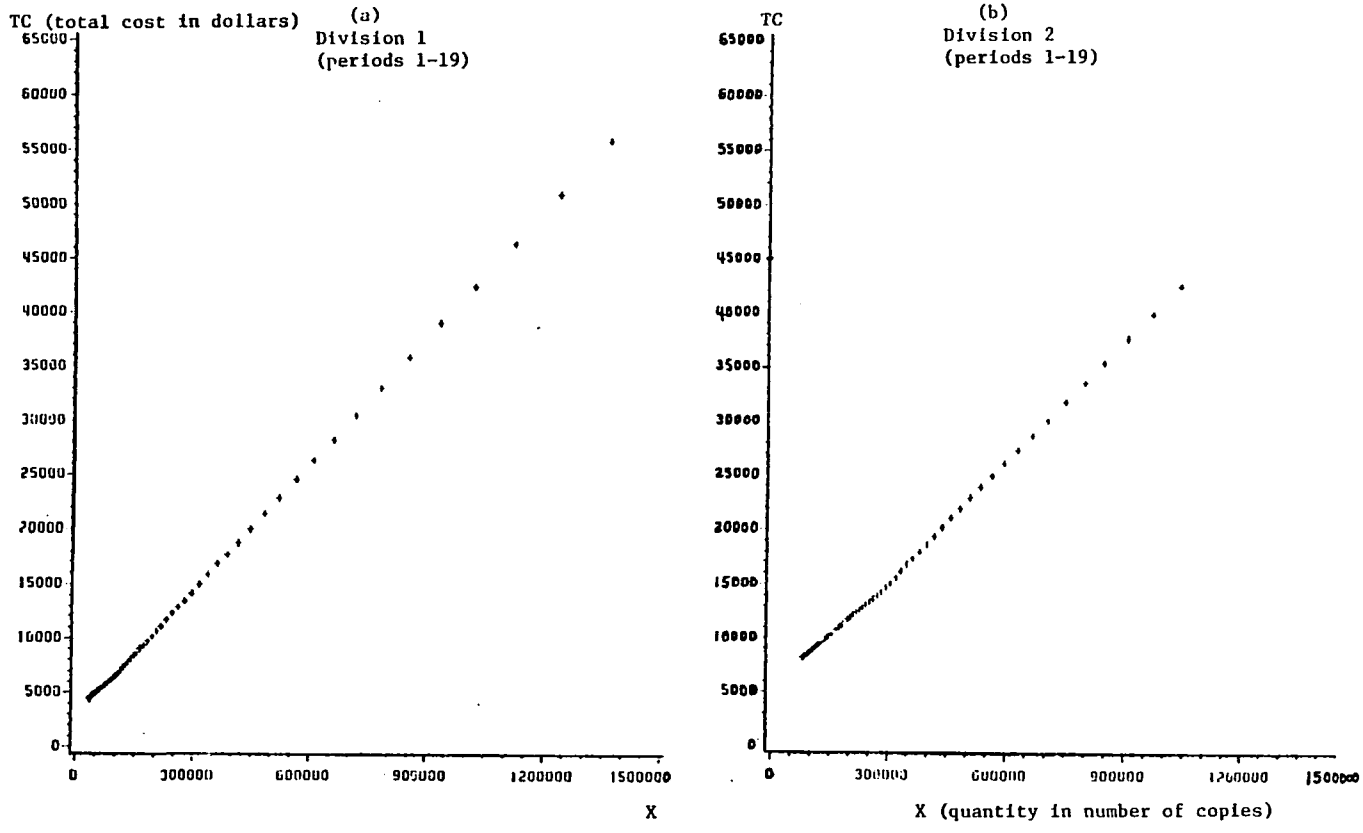


FIGURE 4

COST FUNCTIONS
(JOINT USE OF THE COPIER)

(periods 1-19)

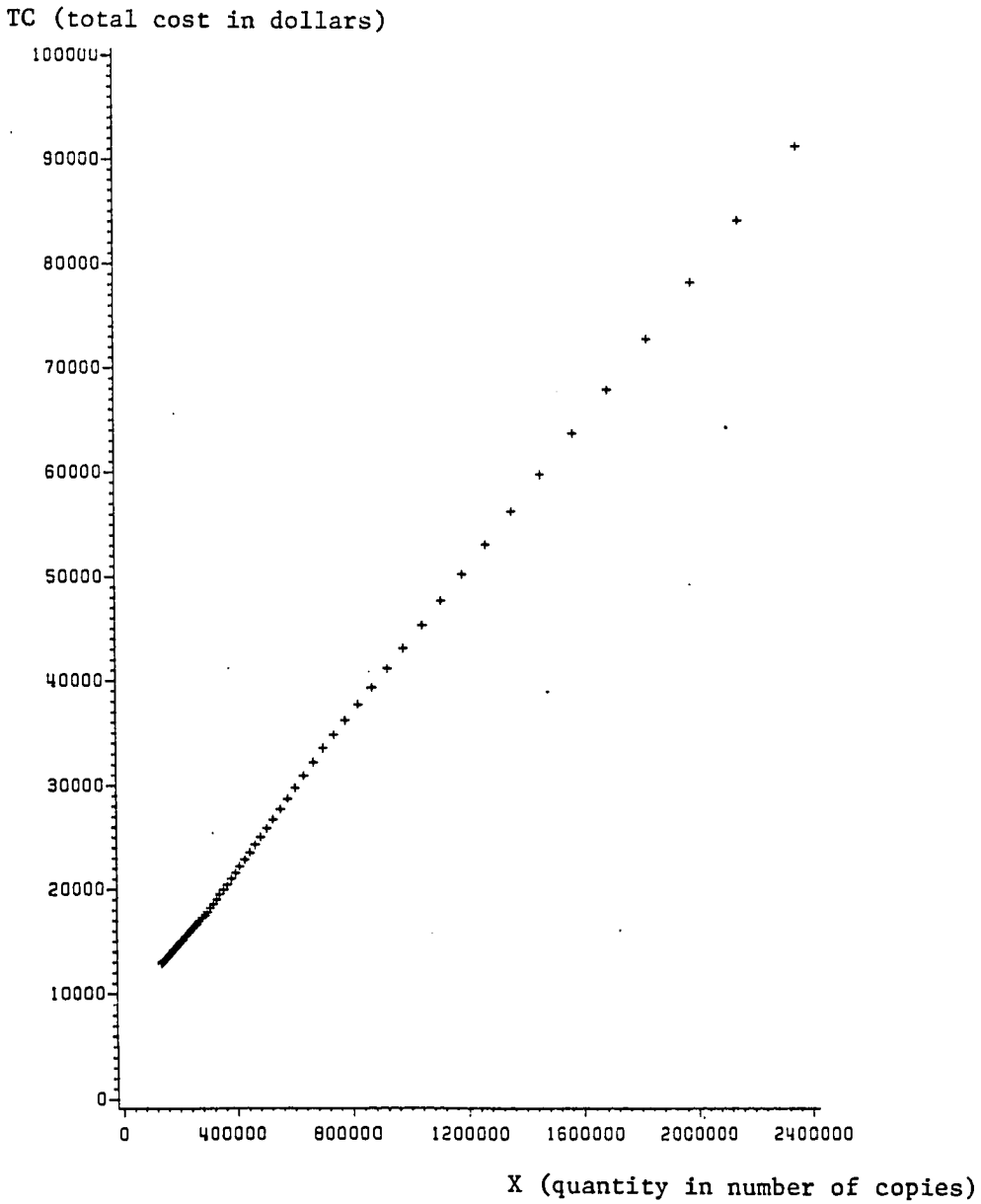


FIGURE 5

THE RELATIONS BETWEEN NET INCOME AND THE SELLING PRICE

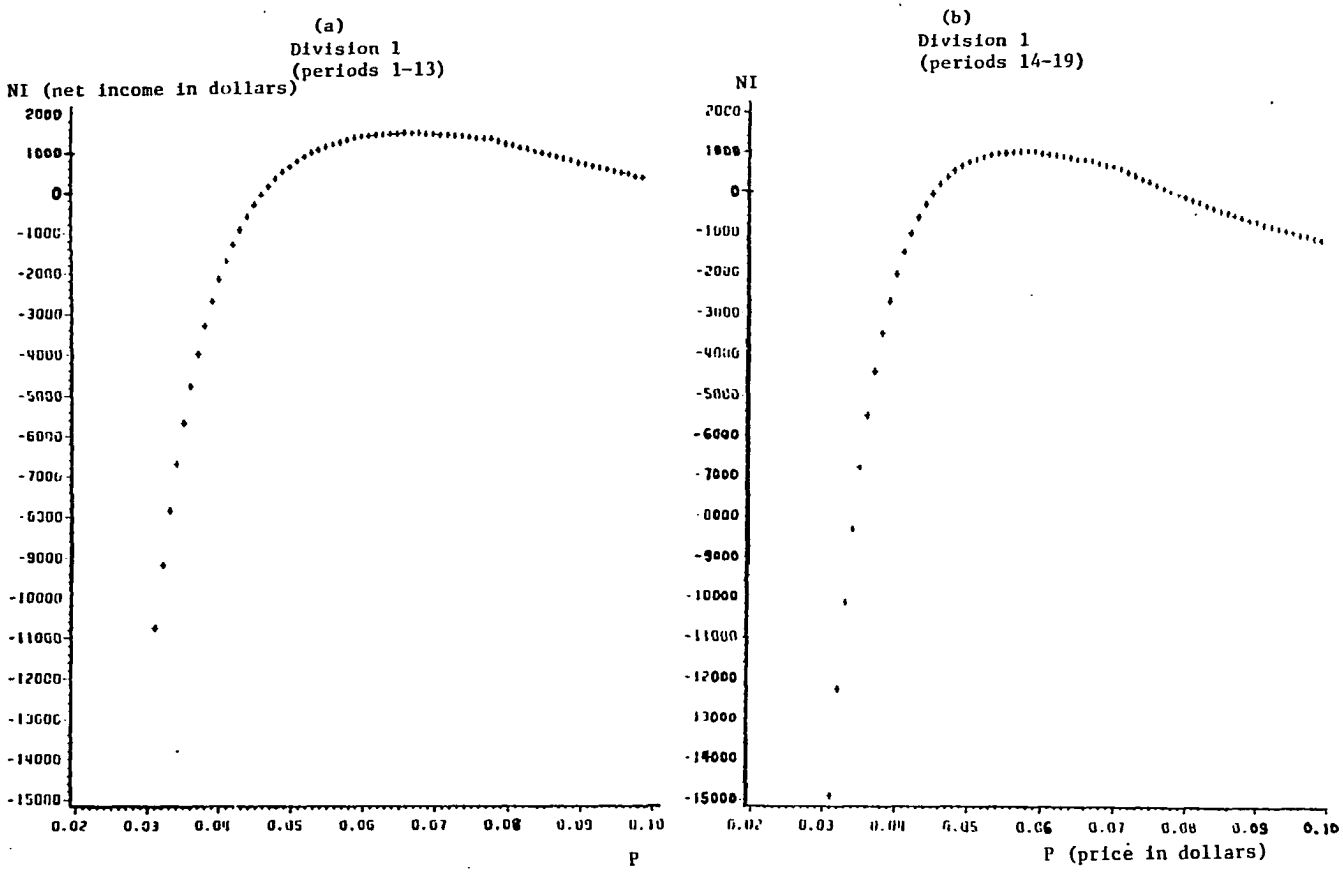
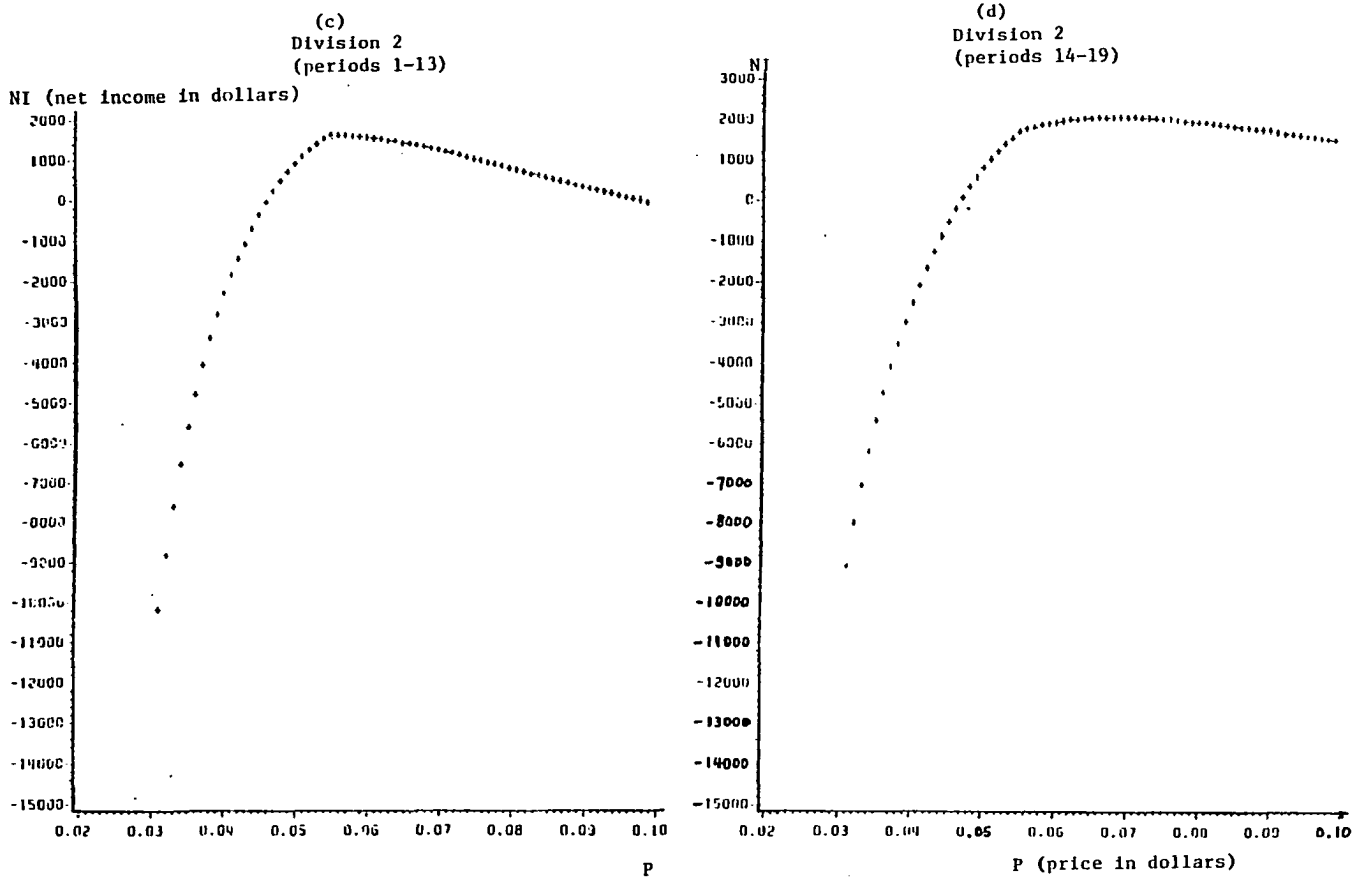


FIGURE 5 (CONTINUED)



were conducted using the net realizable value allocation method (the N method hereafter) and the remaining 30 experiments were performed using the Shapley value allocation method (the S method hereafter). Therefore, in total, there were 30 subjects who took the role of the Division 1 manager under the N method, another 30 subjects acted as the Division 2 manager under the N method, 30 more subjects were assigned as the Division 1 manager under the S method, and a last 30 subjects represented the Division 2 manager under the S method.

Since a series of 60 experiments were conducted there was the danger that the students who performed the experiment early might talk about their experience with students who were to perform the experiment later. In order to minimize this talk, the instructions stated that there were a large number of different experimental environments. Hence any comments made to their friends who were to perform the experiment later might be misleading. This instruction seems to have worked well because when the subjects' pricing performance was reviewed, there was no indication of systematic "better" performance by the later subjects.

The Experimental Task

In conducting each experiment a set of instructions explaining the situation and the subject's task were

distributed to the subjects. The instructions are shown in Appendix B. Each experiment lasted about an hour. In each experiment 19 accounting periods were simulated in which the subjects had to set a selling price. Their major experimental task was to set a selling price at the beginning of each period. They initially set a price based on their own perception of the situation provided in the instructions at the beginning of the experiment. The prices decided by the two subjects were then presented to the experimenter. The experimenter entered these prices into a computer terminal and obtained income statements for each division. Then, the income statements were distributed to the subjects. The subjects revised their price at the beginning of each subsequent period based on the information contained in the income statement for the preceding period. The computer program for making the income statements when the two managers used a different copier independently is shown in Appendix C. Appendix D provides another computer program for preparing the income statements and the comparative information about the two divisions' operations when the two divisions used a common copier. In addition to the major task, at the end of Period 13 the subjects were asked to evaluate the fairness of the joint cost allocation. At the end of Period 19 they were asked whether they wished

to continue using the joint facility and they were again asked to evaluate the fairness of the joint cost allocation.

The subjects performed their task under the following three situations:

(1) The independent use of a copier (Periods 1-8)

The subjects each used an independent copier. They made pricing decisions using the information contained in the income statement which was prepared based on the selling price they set. An example of the income statement is shown in table 6.

The subjects were allowed four practice periods (Periods 1-4) to become familiar with the experimental task. By performing the task in this situation the subjects learned to play the game and obtained some knowledge of the demand function and the profit potential from using an independent copier. The data (net incomes) for Periods 5-8 were used as covariates in the statistical analysis for research questions 1 and 2.

(2) The joint use of a copier (Periods 9-13)

The subjects were forced to use a joint copier, which affected their cost function. But their demand function was the same as in the case of the independent use of a copier. They again made their pricing decisions using the information contained in the income statements provided to them. An example of these income statements is shown in

TABLE 6

THE INCOME STATEMENTS
(INDEPENDENT USE OF THE COPIER)

MONTHLY INCOME STATEMENT OF DIVISION 1 (PERIOD 8)

REVENUE:			
SALES	146347. COPIES * $0.067		$ 9805.25
EXPENSES:			
COPIER RENTAL		$ 2441.39	
SHOP RENTAL		500.00	
SALARY		600.00	
UTILITIES		300.00	
MATERIALS	146347. COPIES * $0.0306	4478.22	8319.61
NET INCOME			$ 1485.64

MONTHLY INCOME STATEMENT OF DIVISION 2 (PERIOD 8)

REVENUE:			
SALES	295331. COPIES * $0.055		$ 16243.21
EXPENSES:			
COPIER RENTAL		$ 3885.00	
SHOP RENTAL		600.00	
SALARY		700.00	
UTILITIES		400.00	
MATERIALS	295331. COPIES * $0.0306	9037.13	14622.13
NET INCOME			$ 1621.08

table 7. The data (net incomes) were used to answer research question 1.

At the end of Period 13 the subjects received a summary of the operating results for the two divisions. An example of this information is shown in table 8. Consulting this information and the explanation given in the instructions about the allocation method, they evaluated the fairness of the joint cost allocation; that is, they answered a question about how fair they felt the allocation of the joint cost was. They were also asked to list the reasons for their feelings. Their evaluation of the fairness of the allocation was measured on a four-point scale and this data was used to answer research question 3.

(3) The joint use of a copier in a changed demand situation (Periods 14-19)

In the last set of trials, the subjects shared the joint copier as they did in Periods 9-13. But, in these latter trials the demand functions each division faced were changed. The task was the same as in Periods 9-13. The data (net incomes) from these trials were used to answer research question 2.

At the end of Period 19 (the last period) the subjects were asked whether they wished to continue using the joint copier. They were also asked to explain the

TABLE 7

THE INCOME STATEMENTS
(JOINT USE OF THE COPIER)

MONTHLY INCOME STATEMENT OF DIVISION 1 (PERIOD 19)

REVENUE:			
SALES	243395. COPIES * $0.054		$ 13143.34
EXPENSES:			
YOUR SHARE OF COPIER RENTAL		$ 3134.21	
SHOP RENTAL		500.00	
SALARY		600.00	
UTILITIES		300.00	
MATERIALS	243395. COPIES * $0.0306	7447.89	11982.10
NET INCOME			$ 1161.23

MONTHLY INCOME STATEMENT OF DIVISION 2 (PERIOD 19)

REVENUE:			
SALES	149910. COPIES * $0.081		$ 12142.68
EXPENSES:			
YOUR SHARE OF COPIER RENTAL		$ 3212.22	
SHOP RENTAL		600.00	
SALARY		700.00	
UTILITIES		400.00	
MATERIALS	149910. COPIES * $0.0306	4587.23	9499.46
NET INCOME			$ 2643.22

TABLE 8

SUMMARY OF THE OPERATING RESULTS FOR THE TWO DIVISIONS

	TOTAL	DIVISION 1	DIVISION 2
1. COPIER RENTAL COST CHARGED TO:	6346.44	3134.21 (49.4 %)	3212.22 (50.6 %)
2. SALES	25286.02	13143.34 (52.0 %)	12142.68 (48.0 %)
3. SHOP RENTAL	1100.00	500.00 (45.5 %)	600.00 (54.5 %)
4. SALARY	1300.00	600.00 (46.2 %)	700.00 (53.8 %)
5. UTILITIES	700.00	300.00 (42.9 %)	400.00 (57.1 %)
6. MATERIALS	12035.12	7447.89 (61.9 %)	4587.23 (38.1 %)
7. NET INCOME	3804.46	1161.23 (30.5 %)	2643.22 (69.5 %)
8. NUMBER OF COPIES SOLD	393305.	243395. (61.9 %)	149910. (38.1 %)
9. NET INCOME BEFORE CHARGE FOR USE OF COPIER	10150.89	4295.45 (42.3 %)	5855.45 (57.7 %)
10. COST IF EACH DIVISION USED A SEPARATE COPIER	7219.23	3334.23 (46.2 %)	3885.00 (53.8 %)
11. COST SAVINGS (LINE 10 MINUS LINE 1)	872.80	200.02 (22.9%)	672.78 (77.1%)

reasons for their choice. The subjects' responses (yes or no) to the first question were used to answer research question 4.

At the end of Period 19 the subjects were once again given a summary of the two divisions' operations. Based on this information they evaluated the fairness of the joint cost allocation again and this data was used to answer research question 3.

The Compensation Given To The Subjects

The subjects were monetarily rewarded for their participation. Each subject was informed at the beginning of the experiment that he or she would receive $4 at the end of the experiment, and in addition, he or she could receive $50 as a bonus if his or her performance in the experiment turned out to be the best among all 30 performances in the 30-subject group to which he or she belonged.

Each subject's performance was measured as follows:

$$PM = \sum_{i=5}^{19} NI_i$$

where PM = performance measure

NI_i = net income earned by a subject in period i

This measurement of each subject's performance is based on the assumption that each subject (manager) is evaluated based on the amount of profit he or she earns. In

fact, the design of the performance evaluation system is very important to a firm in achieving its overall goal. How we chose to measure performance may very well affect subject's pricing decisions. In this study subject's performance was measured using net income in the belief that such a measure is the most commonly used way of evaluating performance in practice.

The Subjects

The ideal subjects for this study would have been actual managers from a business similar to the copy shop. But the limited resources available for this study precluded obtaining such subjects. In this situation researchers commonly use college students enrolled in business courses as surrogates for managers. Initially an effort was made to use students enrolled in the senior level Business Policy course, but an insufficient number of these students volunteered to participate. The next choice was to ask students enrolled in the managerial accounting course to participate. These students are mostly sophomores and juniors.

The subjects participating in the experiment were students enrolled in the Managerial Accounting course at the University of Oklahoma during the Spring term, 1983. A total of 120 students participated. The subjects consisted of 4 freshmen, 65 sophomores, 41 juniors, 8 seniors, 1

graduate, and 1 unclassified student. These were 39 Accounting majors, 27 Finance majors, 39 Management majors, 5 Marketing majors, and 10 non-business majors. Of the 120 subjects, 81 had work experience. They were all volunteers who agreed to participate in the experiment. The request for students' participation in the experiment is shown in Appendix E.

Data Obtained From The Experiment

From the experiment, the following data were obtained:

(1) the selling price set for each period by each manager
(2) the net income earned by each divisional manager for each period
(3) the subjects' indication of the level of fairness of the joint cost allocation (obtained at the end of Periods 13 and 19)
(4) the "yes or no" responses to the question concerning whether to continue using the joint copier (obtained at the end of Period 19)

The above data were obtained for each of the following 30-subject groups:

(1) the Division 1 managers under the N method
(2) the Division 2 managers under the N method
(3) the Division 1 managers under the S method
(4) the Division 2 managers under the S method

The data obtained from the experiment are illustrated in figure 6. The raw data was used to generate the variables used in the analysis as described in the next section.

The Statistical Designs

The statistical analysis of sample data obtained from an experiment attempts to generalize to a larger population. Research questions are answered by testing hypotheses. In order to test the hypotheses appropriate statistical models and variables for the models should be selected. In the following section the statistical designs used for testing the hypotheses, the appropriate models and the variables selected in this study will be described.

Design For Hypotheses 1, 2, and 3

As stated earlier, research question 1 asks about the effect that the two cost allocation methods have on divisional managers' pricing decisions. In order to answer question 1 three null hypotheses were set; the first hypothesis (H(1)) concerns the net incomes earned by the Division 1 managers, the second hypothesis (H(2)) examines the net incomes earned by the Division 2 managers, and the third hypothesis (H(3)) investigates the effect on the firm's overall net income. These hypotheses can be tested by applying the analysis of variance model. The analysis of variance model is a statistical technique used to determine

FIGURE 6

THE RAW DATA FROM THE EXPERIMENT

N method Division 1

Experiment #1

Periods	Selling price (c)	Net income ($)	Fairness measure	Yes or No
5	8.0	1228.10		
6	7.8	1329.52		
7	7.5	1389.73		
8	7.4	1409.07		
9	7.0	1250.98		
10	7.4	1409.07		
11	7.2	1126.52		
12	7.3	1260.91		
13	6.9	1342.40	2	
14	7.5	508.44		
15	6.5	920.52		
16	6.3	997.78		
17	6.0	987.22		
18	6.2	870.16		
19	5.8	1136.05	2	Y

N method Division 2

Experiment #1

Periods	Selling price (c)	Net income ($)	Fairness measure	Yes or No
5	5.2	1272.57		
6	5.7	1625.91		
7	5.9	1592.05		
8	4.9	718.58		
9	5.5	1412.73		
10	7.3	1791.67		
11	8.6	1353.52		
12	6.0	1719.56		
13	6.5	1879.83	2	
14	6.3	1942.18		
15	6.8	2312.21		
16	7.0	2393.75		
17	5.9	1802.13		
18	5.6	1492.82		
19	7.5	2561.37	2	N

S method Division 1

Experiment #31

Periods	Selling price (c)	Net income ($)	Fairness measure	Yes or No
5	7.9	1279.45		
6	7.8	1329.52		
7	7.6	1369.96		
8	7.5	1390.62		
9	6.0	1229.36		
10	8.0	1138.05		
11	7.0	1528.40		
12	6.8	1664.03		
13	6.5	1619.63	3	
14	9.1	-802.09		
15	5.3	787.28		
16	6.8	651.44		
17	4.9	830.81		
18	4.4	-67.07		
19	5.0	1029.42	2	N

S method Division 2

Experiment #31

Periods	Selling price (c)	Net income ($)	Fairness measure	Yes or No
5	5.5	1628.34		
6	5.3	1416.61		
7	5.7	1612.51		
8	5.6	1624.86		
9	5.5	1442.45		
10	5.8	1540.09		
11	6.2	1599.30		
12	6.6	1599.06		
13	6.4	1612.45	2	
14	5.5	1718.19		
15	5.3	1282.11		
16	6.0	1898.33		
17	6.5	2238.16		
18	6.7	2327.12		
19	7.0	2369.03	2	Y

if samples came from populations with equal means. This model may be appropriate whenever the observations are subdivided into identifiable groups. The experiment in this study provides observations on the criterion variables under two identifiable groups, i.e., the N method group and the S method group. Therefore, this model is appropriate for testing the first three hypotheses.

In order to test the above three hypotheses a multivariate analysis of covariance (MANOCOVA hereafter) model was used. The MANOCOVA model adds a covariance analysis to the multivariate analysis of variance (MANOVA hereafter) model. MANOVA is particularly useful for examining interrelated criterion variables, because it allows simultaneous testing for the treatment effect on two or more criterion variables and this "simultaneous" consideration allows control of α-level. Afifi and Azen (1979, p. 86) mentioned the overall significance level of more than one test of hypotheses as follows:

> If the investigator wishes to make more than one test of these hypotheses, then the overall significance level (that is, the significance level of all of his tests combined) may be nowhere near the nominal α. Thus, he is unable to assert that all of his tests were simultaneously made at the α level.

To circumvent this problem, the investigator may use a MANOVA procedure for all of his tests so that he is able to assert that all of the tests are at the α level, that is, the overall level is the nominal α.

During Periods 9-13 of the experiment, divisional managers used a joint copier. Under one set of the experiments divisional net income was determined by allocating the joint cost using the net realizable value method whereas the Shapley value allocation was used for the other set of experiments. In this situation the different cost allocation methods are non-metric predictor variables (independent variables) and the divisional managers' performances in terms of divisional and overall net income are metric criterion variables (dependent variables). To measure how well the divisional managers set selling prices, the absolute difference between the optimal net income and the actual net income as a percentage of the optimal net income was calculated. Algebraically, the measurement is presented as follows:

$$|NI^*(i) - NI(i)|/NI^*(i)$$

where $NI^*(i)$= the optimal net income for Division i (i= 1, 2)

$NI(i)$ = the actual net income earned by Division i managers

Similarly, the absolute difference between the optimal overall net income and the overall net income actually earned as a percentage of the optimal overall net income was calculated. The measurement is algebraically shown below.

$$|ONI^* - ONI|/ONI^*$$

where ONI^*= the optimal overall net income

ONI = the overall net income actually earned by the two managers

The first two hypotheses are concerned with the effect of the two different allocation methods on the individual divisional managers' pricing performance while the third hypothesis examines the effect of the methods on the firm's overall profit position. Since these three criteria are interrelated, MANOVA is appropriate to test these three hypotheses simultaneously.

In investigating whether there is any significantly different effect on the criterion variables between the two different allocation schemes, it is necessary to control for any differences in the subjects' innate ability across treatments. To remove these extraneous influences a covariance analysis can be used. Hair, Anderson, Tatham, and Grablowsky (1979, p. 146) address the merits of covariate analysis:

> Use of multivariate analysis of covariance (MANOCOVA) with MANOVA improves the precision of an experiment by removing possible sources of variance in the criterion variable that may be accounted for by metric independent variables not controlled in the experimental design. Removing these extraneous influences reduces the residual error, thereby increasing the "pure" effect of the treatment variables.

During Periods 1-8 of the experiment each divisional manager used his or her own copier. There was no allocation of joint cost and therefore their decisions were unaffected by the two different allocation methods. A measure of each subject's performance during these trials

was used as a measure of innate ability. On the assumption that subjects' performance improved as periods went on, the 8th period's performances were selected as the covariates for testing the first three hypotheses in this study.

Using subjects' performances during Periods 9-13 of the experiment as dependent variables, a MANOCOVA was performed for each period. The MANOCOVA model can be presented as follows:

$$\left[{}_{k}Y^{(1)}_{ij},\ {}_{k}Y^{(2)}_{ij},\ {}_{k}Y^{(3)}_{ij}\right] = \left[\mu^{(1)},\ \mu^{(2)},\mu^{(3)}\right] + \left[\alpha^{(1)}_{j},\ \alpha^{(2)}_{j},\alpha^{(3)}_{j}\right] + \left[\beta^{(1)}X^{(1)}_{ij},\ \beta^{(2)}X^{(2)}_{ij},\ \beta^{(3)}X^{(3)}_{ij}\right] + \left[\varepsilon^{(1)}_{ij}\varepsilon^{(2)}_{ij},\ \varepsilon^{(3)}_{ij}\right]$$

where subscript i = observations (i=1,...,30)

subscript j = allocation methods
(j=1; the N method
j=2; the S method)

subscript k = Periods (k= 9, 10, 11, 12, 13)

${}_{k}Y^{(1)}_{ij}$ = the percentage of the absolute difference between the optimal net income and the actual net income earned by the Division 1 manager relative to the optimal net income for observation i in the jth subclass in Period k

${}_{k}Y^{(2)}_{ij}$ = the percentage of the absolute difference between the optimal net income and the actual net income earned by the Division 2 manager relative to the optimal net income for observation i in the jth subclass in Period k

${}_{k}Y^{(3)}_{ij}$ = the percentage of the absolute difference between the optimal overall net income and the overall net income actually earned by the firm relative to the optimal overall net income for observation i in the jth subclass in Period k

$\mu^{(1)}$ = a fixed parameter representing the population mean of the first criterion variable

$\mu^{(2)}$ = a fixed parameter representing the population mean of the second criterion variable

$\mu^{(3)}$ = a fixed parameter representing the population mean of the third criterion variable

$\alpha_j^{(1)}$ = the fixed mean deviation from $\mu^{(1)}$, of the observations in subclass j

$\alpha_j^{(2)}$ = the fixed mean deviation from $\mu^{(2)}$, of the observations in subclass j

$\alpha_j^{(3)}$ = the fixed mean deviation from $\mu^{(3)}$, of the observations in subclass j

$X_{ij}^{(1)}$ = the percentage of the absolute difference between the optimal net income and the actual net income earned by the Division 1 manager relative to the optimal net income for observation i in the jth subclass in Period 8

$X_{ij}^{(2)}$ = the percentage of the absolute difference between the optimal net income and the actual net income earned by the Division 2 manager relative to the optimal net income for observation i in the jth subclass in Period 8

$X_{ij}^{(3)}$ = the percentage of the absolute difference between the optimal overall net income and the overall net income actually earned by the firm relative to the optimal overall net income for observation i in the jth subclass in period 8

$\beta^{(1)}$ = coefficient of covariate $X_{ij}^{(1)}$

$\beta^{(2)}$ = coefficient of covariate $X_{ij}^{(2)}$

$\beta^{(3)}$ = coefficient of covariate $X_{ij}^{(3)}$

$\varepsilon_{ij}^{(1)}$ = the random deviation of observation i in subclass j from the subclass mean of the first criterion variable

$\varepsilon_{ij}^{(2)}$ = the random deviation of observation i in subclass j from the subclass mean of the second criterion variable

$\varepsilon_{ij}^{(3)}$ = the random deviation of observation i in subclass j from the subclass mean of the third criterion variable

There are two types of effects that can be studied in analysis of variance designs. In the fixed effects

design, no attempt is made to infer beyond the specific levels of the factors actually incorporated in the experiment. In the random effects design, however, the factor levels are chosen randomly from the population of levels of interest to a researcher. Inferences in the latter case can then be made to the entire population of levels. In the above MANOCOVA design the non-metric independent variables are "fixed." Since the factor levels (i.e., the two different allocation schemes) constitutes the entire population of research interest, the design is a fixed-effects model and no effort is made to infer beyond the groups being analyzed.

In order to determine the significance of the overall main effects in the above MANOCOVA design, Wilks's lambda statistic was used. The test statistic is presented below (Harris, 1975, p. 109).

$$\Lambda = |E|/|H+E| = 1/|E^{-1}H+I|$$

where E = the within-group covariance matrix

H = the between-group covariance matrix

I = the identity matrix

Most texts and most computer programs employ the Wilks's lambda criteria for significance tests in MANOVA. The reasons for this preference are stated by Harris (1975, p. 109) as follows:

> (a) historical precedence.
> (b) while the exact distribution of U (Λ) is extremely complex, fairly good approximations to this

distribution in terms of readily available chi-square and F-table entries exist.

(c) under certain circumstances, especially for data where the successive characteristic roots of $E^{-1}H$ are nearly equal, statistical tests based on U (Λ) are more powerful than greatest characteristic root (gcr) tests.

(d) determinants are easier to compute than are characteristic roots.

Several conditions must be met for the proper application of the MANOVA. According to Hair et al. (1979, pp. 145-159) the assumptions underlying MANOVA can be summarized as follows:

(1) Random sampling

(2) The observations within cells should be independent.

(3) The set of dependent variables should be jointly normally distributed.

(4) The error variance should be equal among the cells (the treatment groups).

Since this study employed volunteer subjects from an available pool, it does not constitute random sampling, but the lack of random sampling will not seriously distort any conclusions. It is questionable whether or not the distributional assumptions for MANOCOVA are met in the observations made in this study. In commenting on the effects of violations of distributional assumptions in multivariate analysis, Harris (1975, pp. 231-233) is quite optimistic about the robustness of multivariate tests, so long as the treatment groups have the same sample size and the sample size is sufficiently large. Harris (1975, p.

233) further states:

> The issue of robustness of multivariate tests is the focus of a great deal of current effort by mathematical statisticians, and large strides can be expected within the next few years. Most indications are that multivariate techniques will prove as robust as their univariate counterparts.

In addition to the MANOVA assumptions, there are additional conditions to be met to make MANOCOVA effective. That is, MANOCOVA is appropriate only when the relationship between the covariates and the criterion variables is linear, and wnen there is no interaction between covariates and non-metric independent variables (Hair et al., 1979, p. 146). The second condition seems to be satisfied in this study. But, it is not clear whether or not the first condition is met in this study. Therefore, the MANOCOVA model applied in this study will be effective only to the extent that the relationship between the covariates and the criterion variables is close to linear. However, linear models are frequently found to be excellent approximations to the types of non-linear models found in experimental studies similar to this study.

Design For Hypotheses 4, 5, and 6

As mentioned earlier, research question 2 is concerned with whether there is a significant difference between the two allocation schemes in their effect on the divisional managers' ability to adjust prices when the demand function changes. Hypotheses 4, 5, and 6 were set to

answer this question. The fourth hypothesis (H(4)) concerns the net incomes earned by the Division 1 managers when the demand function changed, the fifth hypothesis (H(5)) examines the net incomes earned by the Division 2 managers, and the sixth hypothesis (H(6)) investigates the effect on the firm's overall net income when the demand function changed.

In order to test the above three hypotheses a MANOCOVA model was applied. Since the test of these three hypotheses is similar to the test of the first three hypotheses, the discussion in the previous section on the MANOCOVA model also applies here. The model can be presented in exactly the same form as shown on page 63. The MANOCOVA was performed for each period using the subjects' performances during Periods 14-19 as the dependent variables.

Design For Hypotheses 7 and 8

Research question 3 addresses the difference between the two allocation schemes in terms of their perceived fairness in the division of joint cost. Two hypothesis tests were used to answer this question. The seventh hypothesis (H(7)) investigates any significant difference in the divisional managers' combined perceived level of fairness concerning the allocation of the joint cost under the two allocation schemes. The eighth

hypothesis (H(8)) searches for differences in the perceptions of the fairness of the joint cost allocation between the two divisional managers under the two allocation schemes.

In the experiment, the divisional managers evaluated the fairness of the joint cost allocation by indicating their perceived level of fairness on a four-point scale. The criterion variable for the seventh hypothesis is the divisional managers' perceived level of fairness concerning the allocation of the joint cost. For this variable the two managers' fairness scores in each pair were summed. The summed scores indicate how the two divisional managers together felt about the joint cost allocation. However, this measure is not sufficient to capture whether the divisional managers will cooperate in using a facility jointly, when doing so is beneficial to the firm. If the two managers disagree about the fairness of an allocation, they might not cooperate. In the preveious measure of fairness, there could be a situation in which a pair of divisional managers show the same summed fairness score as that shown by another pair of managers, but the managers in one pair might have similar scores whereas the managers in another pair may feel very differently about the fairness. For example, the first Division 1 manager might circle fairness point 2 (i.e., the manager feels the allocation is a little unfair) and the first Division 2 manager might select point

3 (i.e., the manager feels the allocation is moderately fair). On the other hand, the second Division 1 manager might pick point 1 (i.e., the manager feels the allocation is very unfair) and the second Division 2 manager might select point 4 (i.e., the manager feels the allocation is very fair). This example shows that even though the two pairs of divisional managers indicate the same summed score of 5, managers in the first pair are more in agreement than the second pair. Because the managers in the second pair feel so differently about the fairness of the allocation, they might discontinue the joint use of the copier. The eighth hypothesis was formulated to capture this situation. For the eighth hypothesis the criterion variable is the level of disparity between the fairness perceptions between the two managers. For this variable the absolute difference between the two subjects' fairness scores was calculated for each pair.

In the experiment the divisional managers evaluated the fairness of the joint cost allocation at two times; first at the end of Period 13, and second at the end of Period 19. When the managers evaluated the fairness at the end of Period 13 they were informed of how the allocation of the joint cost was made. Prior to the end of Period 13 the managers did not know how the joint cost was allocated. The managers evaluated the fairness again at the end of Period 19 because it was felt that there might be some change in

the managers' perceptions of the fairness of the allocation after they could change their strategy when knowing how the allocation was calculated.

Hypotheses H(7) and H(8) were tested by again using a MANOVA model and a MANOCOVA model. MANOVA was applied using the observations of the managers' evaluation of the fairness at the end of Period 13. The MANOVA model is presented below.

$$\left[{}_{13}F_{ij}^{(1)},\ {}_{13}F_{ij}^{(2)}\right] = \left[\mu^{(1)},\ \mu^{(2)}\right] + \left[\alpha_j^{(1)},\ \alpha_j^{(2)}\right] + \left[\varepsilon_{ij}^{(1)}\ \varepsilon_{ij}^{(2)}\right]$$

where subscript i = observations (i=1,...,30)

subscript j = allocation methods
(j=1; the N method
j=2; the S method)

${}_{13}F_{ij}^{(1)}$ = the sum of the two managers' fairness scores for observation i in the jth subclass in Period 13

${}_{13}F_{ij}^{(2)}$ = the absolute difference between the two managers' fairness scores for observation i in the jth subclass in Period 13

$\mu^{(1)}$ = a fixed parameter representing the population mean of the first criterion variable

$\mu^{(2)}$ = a fixed parameter representing the population mean of the second criterion variable

$\alpha_j^{(1)}$ = the fixed mean deviation from $\mu^{(1)}$, of the observations in subclass j

$\alpha_j^{(2)}$ = the fixed mean deviation from $\mu^{(2)}$, of the observations in subclass j

$\varepsilon_{ij}^{(1)}$ = the random deviation of observation i in subclass j from the subclass mean of the first criterion variable

$\varepsilon_{ij}^{(2)}$ = the random deviation of observation i in subclass j from the subclass mean of the second criterion variable

MANOCOVA was applied using the observations of the managers' evaluation of the fairness at the end of Period 19. The MANOCOVA model is shown below.

$$\left[{}_{19}F_{ij}^{(1)}, {}_{19}F_{ij}^{(2)}\right] = \left[\mu^{(1)}, \mu^{(2)}\right] + \left[\alpha_j^{(1)}, \alpha_j^{(2)}\right] + \left[\beta_{13}^{(1)} {}_{13}F_{ij}^{(1)}, \beta_{13}^{(2)} {}_{13}F_{ij}^{(2)}\right] + \left[\varepsilon_{ij}^{(1)}, \varepsilon_{ij}^{(2)}\right]$$

where subscript i = observations (i=1,...,30)

subscript j = allocation methods
(j=1; the N method
j=2; the S method)

${}_{19}F_{ij}^{(1)}$ = the sum of the two managers' fairness scores for observation i in the jth subclass in Period 19

${}_{19}F_{ij}^{(2)}$ = the absolute difference between the two managers' fairness scores for observation i in the jth subclass in Period 19

$\mu^{(1)}$ = a fixed parameter representing the population mean of the first criterion variable

$\mu^{(2)}$ = a fixed parameter representing the population mean of the second criterion variable

$\alpha_j^{(1)}$ = the fixed mean deviation from $\mu^{(1)}$, of the observations in subclass j

$\alpha_j^{(2)}$ = the fixed mean deviation from $\mu^{(2)}$, of the observations in subclass j

${}_{13}F_{ij}^{(1)}$ = the sum of the two managers' fairness scores for observation i in the jth subclass in Period 13

${}_{13}F_{ij}^{(2)}$ = the absolute difference between the two managers' fairness scores for observation i in the jth subclass in Period 13

$\beta^{(1)}$ = coefficient of covariate ${}_{13}F_{ij}^{(1)}$

$\beta^{(2)}$ = coefficient of covariate ${}_{13}F_{ij}^{(2)}$

$\varepsilon_{ij}^{(1)}$ = the random deviation of observation i in subclass j from the subclass mean of the first criterion variable

$\varepsilon_{ij}^{(2)}$ = the random deviation of observation i in subclass j from the subclass mean of the second criterion variable

Design For Hypothesis 9

Research question 4 concerns whether the managers are more willing to cooperate in the use of a joint facility under one allocation scheme versus the other. To answer this question the ninth hypothesis (H(9)) was set. The criterion variable for this hypothesis is the managers' "yes or no" response to the question of whether they wished to continue using a copier jointly. At the end of Period 19 of the experiment, the managers answered yes or no to this question. Two proportions were calculated; one is the proportion of "yes" answers out of each group of 60 subjects, and the other is the proportion of simultaneous "yes" answers by both subjects in a pair. The first proportion was considered because it indicates the degree to which divisional managers are encouraged to continue using the joint copier. The second proportion was considered because it shows the extent to which both managers agree to continued cooperation.

Student t-test's were used to test hypothesis H(9). At first a t-test was performed using the first proportion (denoted as PY) as the criterion variable and then another t-test was performed using the second proportion (denoted as PYY) as the criterion variable.

The null hypothesis for the first t-test is presented below.

$H(9)_1 : PY_n = PY_s$

where PY_n = proportion of "yes" answers under the N method

PY_s = proportion of "yes" answers under the S method

The null hypothesis for the second t-test is presented below.

$H(9)_2 : PYY_n = PYY_s$

where PYY_n = proportion of simultaneous "yes" answers by both managers under the N method

PYY_s = proportion of simultaneous "yes" answers by both managers under the S method

The appropriate test statistic in this case is the t statistic as shown below.

$$t = (P_1 - P_2) - (\hat{P}_1 - \hat{P}_2) \; / \; \hat{\sigma}_p$$

where P_1 = true proportion of group 1

P_2 = true proportion of group 2

$\hat{P}_1$ = estimate of P_1

$\hat{P}_2$ = estimate of P_2

$\hat{\sigma}_p$ = estimate of the standard deviation of the sample pooled proportions

$$= \sqrt{\hat{P}(1-\hat{P})((1/N_1)+(1/N_2))}$$

where N_1 = sample size of group 1

N_2 = sample size of group 2

$\hat{P}$ = estimate of pooled proportion

$= (N_1\hat{P}_1 + N_2\hat{P}_2)/(N_1+N_2)$

The null hypothesis to be tested implies that the

variances of the two populations are equal. This is a necessary assumption for the t test in this situation.

The statistical models and variables for the research questions and the hypotheses are summarized in table 9.

TABLE 9

THE STATISTICAL MODELS AND VARIABLES

Q*	H**	Statistical models	Variables: Dependent	Variables: Independent	Variables: Covariate
1	H(1)	MANOCOVA	$_{k}Y^{(1)}_{ij}$	Method	$X^{(1)}_{ij}$
	H(2)		$_{k}Y^{(2)}_{ij}$		$X^{(2)}_{ij}$
	H(3)		$_{k}Y^{(3)}_{ij}$		$X^{(3)}_{ij}$
2	H(4)	MANOCOVA	$_{k}Y^{(1)}_{ij}$	Method	$X^{(1)}_{ij}$
	H(5)		$_{k}Y^{(2)}_{ij}$		$X^{(2)}_{ij}$
	H(6)		$_{k}Y^{(3)}_{ij}$		$X^{(3)}_{ij}$
3	H(7)	MANOVA	$F^{(1)}_{13\ ij}, F^{(2)}_{13\ ij}$	Method	-
	H(8)	MANOCOVA	$F^{(1)}_{19\ ij}, F^{(2)}_{19\ ij}$	Method	$F^{(1)}_{13\ ij}, F^{(2)}_{13\ ij}$
4	H(9)	t- test	PY	Method	-
			PYY	Method	-

* Q stands for research questions.
** H stands for hypotheses.

Summary

This chapter presented the specific research

questions addressed in this study. Hypotheses were then stated for each question. Next, the experiments used for gathering data relevent for the testing of the hypotheses was described. Finally, the chapter described the statistical design to be used for analyzing the data. The results from these statistical tests will follow in the next chapter.

CHAPTER IV

THE RESULTS OF THE STATISTICAL TESTS

Introduction

This chapter presents the results of the statistical tests for each statistical design described in Chapter III. Before presenting the results, the performance measures calculated from the raw data for the statistical designs are briefly discussed.

Statistical Results By Design

Design for Hypotheses 1, 2, and 3

The first hypothesis was included to determine whether there is any difference between the N method and the S method in leading the Division 1 managers to set prices that render net incomes closer to the optimal net income. The performance measure used to evaluate managers' pricing performance was the absolute difference between the optimal net income for Division 1 and the actual net incomes earned by the Division 1 managers as a percentage of the optimal net income for Period 8 and Periods 9-13.

The second hypothesis concerned whether there was any difference between the N method and the S method in leading the Division 2 managers to set prices that render net incomes closer to the optimal net income. Again the performance measure was the absolute difference between the optimal net income for Division 2 and the actual net incomes earned by the Division 2 managers as a percentage of the optimal net income for Period 8 and Periods 9-13.

The third hypothesis investigated whether there was any difference between the firm's overall net income under the N method and the S method. For this hypothesis the absolute difference between the optimal overall net income and the total net income actually earned by both managers as a percentage of the optimal overall net income for Period 8 and Periods 9-13 was calculated. Mean values for the managers' performance under each method in percentage terms appear in table 10.

The MANOCOVA model described in Chapter III was applied for each period (Periods 9-13) using the Statistical Analysis System package (SAS hereafter) to test the first three hypotheses. The managers' performance measures for Period 8 were used as covariates. First, the Wilks's lambda (Λ) statistic was investigated to determine the significance of the overall treatment effects in the MANOCOVA model. In SAS, however, the distribution of Λ was transformed into the F distribution so that the readily

TABLE 10

MEAN VALUES FOR THE MANAGERS' PERFORMANCE
(PERIODS 9-13 WITH PERIOD 8)

Period	Division 1 managers' performance(1)		Division 2 managers' performance(2)		Overall net income performance(3)	
	N method	S method	N method	S method	N method	S method
8	2.82%	1.52%	7.39%	3.67%	5.18%	2.60%
9	29.72	32.80	38.40	32.68	34.78	31.83
10	16.66	25.46	25.92	19.93	21.91	21.41
11	13.93	20.76	16.54	5.58	15.44	11.13
12	6.33	14.71	9.18	7.54	7.92	8.13
13	4.49	14.45	6.30	5.48	5.55	7.09

(1) The percentage of the absolute difference between the optimal net income for Division 1 and the actual net income earned by the Division 1 managers.

(2) The percentage of the absolute difference between the optimal net income for Division 2 and the actual net income earned by the Division 2 managers.

(3) The percentage of the absolute difference between the optimal overall net income and the actual overall net income earned by the managers.

available F-table can be used. If the calculated Λ were significant at the .01 level, then the univariate analysis of variance was performed to determine which criterion variable was affected by the difference in the allocation schemes. Table 11 shows the Wilks's lambda statistics, the transformed F statistics, the P values associated with the

transformed F statistics, and the P values associated with the univariate F statistics for Periods 9-13.

TABLE 11

TEST STATISTICS (PERIODS 9-13)

Period	Λ	F(t)	P(t)	P(1)	P(2)	P(3)
9	.8559	2.97	.0393	.8307	.9306	.8518
10	.6881	8.01	.0002*	.2929	.6188	.6652
11	.6375	10.05	.0001*	.6631	.0576	.6246
12	.4086	25.57	.0001*	.0015*	.5236	.7736
13	.2804	45.34	.0001*	.0001*	.2220	.3656

Note: Λ = the Wilks's lambda statistic

F(t) = the transformed F statistic

P(t) = P value associated with the transformed F statistic

P(1) = P value associated with the F statistic of the first criterion variable

P(2) = P value associated with the F statistic of the second criterion variable

P(3) = P value associated with the F statistic of the third criterion variable

* indicates significant difference at .01 level.

In table 11, test statistics for Periods 9-12 were provided for background information and the analysis was made on only the statistics for Period 13. As shown in table 11, for Period 13, P(t) is .0001 which indicates a

significant difference at the .01 level. This P value signals that a significant difference exists between the multivariate normal distribution of the three criterion variables under the N method and that under the S method. In order to determine which criterion variable was affected by the different treatments (the N method or the S method), it is necessary to examine each univariate F statistic and its associated P value. In table 11 for Period 13, only P(1) shows a significant difference at the .01 level (P(1)= .0001). This P value indicates that the Division 1 managers under the N method made pricing decisions quite differently from those under the S method. Table 10 shows the managers' different pricing performance. In table 10, the managers' mean perfomances for Periods 8-12 were provided for background information and the analysis was made on only the performances for Period 13. In table 10 for Period 13 it can be seen that the Division 1 managers under the N method, on the average, set selling prices so that their net incomes are only 4.49% away from the optimal net income, whereas those under the S method, on the average, set selling prices which resulted in net incomes that are 14.45% away from the optimal net income. Based on these statistics, the first hypothesis (H(1)) can be rejected and it is concluded that the N method leads the Division 1 managers to prices that render net incomes closer to the optimal net incomes. In other words, the net realizable value allocation scheme is

"better" than the Shapley value allocation scheme for the Division 1 managers' pricing decisions.

In table 11 for Period 13, P(2) and P(3) do not show significant differences at the .01 level: (P(2)= .2220 and P(3)= .3656). In table 10 for Period 13 it can be seen that, on the average, both the Division 2 managers under the N method and those under the S method did well in their pricing decisions, showing respectively 6.30% and 5.48% deviations from the optimal net income. Therefore, the second hypothesis (H(2)) cannot be rejected and it is concluded that the difference in allocation schemes did not affect the Division 2 managers' pricing decisions. Table 10, Period 13 also shows that, on the average, both the overall net incomes under the N method and those under the S method were relatively good (5.55% deviation under the N method and 7.09% deviation under the S method from the optimal overall net income). Therefore, the third hypothesis (H(3)) cannot be rejected and a conclusion can be drawn that the firm's overall profit position was not affected by the difference in allocation schemes.

Design for Hypotheses 4, 5, and 6

The fourth, fifth, and sixth hypotheses were formulated to see whether any difference exists between the N method and the S method when divisional managers must adapt to a change in the demand function. In the

experiment, the demand function changed for Periods 14-19. The managers' performances were measured in the same manner as in the previous section. Mean values for the managers' performance under each method, in percentage terms, appear in table 12.

The MANOCOVA model was applied for each period (Periods 14-19) using SAS to test the fourth, fifth, and sixth hypotheses. The managers' performance measures for Period 8 were again used as covariates. As with the previous section, the Wilks's lambda, the F transformation of the lambda, and the multivariate P value were first investigated and when these multivariate statistics showed a significant difference, the univariate analysis of variance was performed to see which criterion variable was affected by the difference in allocation methods. Table 13 shows the Wilks's lambda statistics, the transformed F statistics, the P values associated with the transformed F statistics, and the P values associated with each univariate F statistics for Periods 14-19.

As mentioned in the previous section, the analysis was made on only the statistics for Period 19. In table 13 for Period 19, P(t) shows a significant difference at the .01 level between the two allocation schemes on the three criterion variables. Therefore, univariate P values were calculated to find out which criterion variable was affected by the difference in allocation schemes. In table 13 for

TABLE 12

MEAN VALUES FOR THE MANAGERS' PERFORMANCE
(PERIODS 14-19 WITH PERIOD 8)

Period	Division 1 managers' performance(1)		Division 2 managers' performance(2)		Overall net income performance(3)	
	N method	S method	N method	S method	N method	S method
8	2.82%	1.52%	7.39%	3.67%	5.18%	2.60%
14	51.61	77.67	44.85	24.17	46.60	44.76
15	17.83	48.59	21.71	15.43	20.44	28.05
16	24.21	27.36	19.38	9.50	19.81	16.04
17	14.74	24.31	15.40	9.15	14.86	13.68
18	8.91	19.19	10.79	8.23	10.03	11.52
19	4.61	13.98	7.57	6.91	6.51	8.03

(1) The percentage of the absolute difference between the optimal net income for Division i and the actual net income earned by the Division 1 managers.

(2) The percentage of the absolute difference between the optimal net income for Division 2 and the actual net income earned by the Division 2 managers.

(3) The percentage of the absolute difference between the optimal overall net income and the actual overall net income earned by the managers.

Period 19, only P(1) shows a significant difference at the .01 level: (P(1)= .0047, P(2)= .1987, P(3)= .7006). Thus, only the Division 1 managers' pricing decisions were affected by the difference in allocation methods. Table 12 shows how the two allocation schemes affected the divisional

TABLE 13

TEST STATISTICS (PERIODS 14-19)

Period	Λ	F(t)	P(t)	P(1)	P(2)	P(3)
14	.7882	4.75	.0054*	.0896	.1878	.8839
15	.6479	9.60	.0001*	.0036*	.4987	.3535
16	.8330	3.54	.0204	.3214	.0580	.7123
17	.7433	6.10	.0013*	.0171	.0404	.0632
18	.7323	6.46	.0009*	.0900	.0010*	.0929
19	.4535	21.29	.0001*	.0047*	.1987	.7006

Note: Λ = the Wilks's lambda statistic

F(t) = the transformed F statistic

P(t) = P value associated with the transformed F statistic

P(1) = P value associated with the F statistic of the first criterion variable

P(2) = P value associated with the F statistic of the second criterion variable

P(3) = P value associated with the F statistic of the third criterion variable

* indicates significant difference at .01 level.

managers' ability to adjust selling prices to the changed demand function. As stated in the previous section, the analysis was made on only the managers' performances for Period 19. Table 12 at Period 19 shows that the Division 1 managers under the N method, on the average, adapted to the changed function far better than those under the S method.

The net incomes earned by those under the N method are, on the average, 4.61% away from the optimal net income, whereas the net incomes earned by those under the S method were, on the average, 13.98% away from the optimal net income. Therefore, the fourth hypothesis (H(4)) can be rejected and it appears that the net realizable value allocation scheme is "better" than the Shapley value allocation scheme in helping the Division 1 managers adjust to a new demand function. In table 12 for Period 19, both the Division 2 managers' net incomes and the firm's overall net incomes show, on the average, less than ten percent deviation from the respective optimal net income (in the Division 2 managers' performance, 7.57% deviation under the N method and 6.91% deviation under the S method; in the overall net income performance, 6.51% deviation under the N method and 8.03% deviation under the S method from the respective optimal net income). These statistics do not indicate a significant difference under the two allocation schemes. Therefore, the fifth and the sixth hypotheses (H(5) and H(6)) are not rejected and it appears that the difference in allocation methods did not affect the Division 2 managers' pricing decisions nor the firm's overall profit position when adjusting to a changed demand function.

Design for Hypotheses 7 and 8

The seventh hypothesis examines whether any

difference exists in the divisional managers' perceived level of fairness concerning the allocation of the joint cost under the two allocation schemes. For this hypothesis the two managers' scores on the perceived fairness question were summed. Therefore, the perceived level for a pair of subjects ranges from 2 to 8. The larger the fairness measures, the more fair the allocation is perceived to be, and the more likely the managers may be to continue the joint use of a copier.

The eighth hypothesis was formulated to see how differently the managers in a pair perceive the fairness of the joint cost allocation under the two allocation schemes. In order to measure the level of disparity in fairness perception between the two managers, the absolute difference was calculated between the two fairness scores provided by the two managers both at the end of Period 13 and Period 19. Therefore, the level of disparity in the fairness perception measure ranges from 0 to 3. The larger the absolute difference, the greater the disparity in perceived fairness between the two managers and the more likely they may be to discontinue the joint use of the copier. Mean values for the fairness measures under each method are shown in table 14.

The MANOVA model described in Chapter III was applied for Period 13 using SAS to test the two hypotheses. The Wilks's lambda statistic is .9727, the transformed F

TABLE 14

MEAN VALUES FOR THE FAIRNESS MEASURES

Period	Fairness overall measure(1)		Fairness difference measure(2)	
	N method	S method	N method	S method
13	5.4667	5.7000	1.3333	1.1000
19	5.6667	5.6000	1.0667	.7333

(1) The sum of the two managers' fairness scores.

(2) The absolute difference between the two managers' fairness scores.

statistic is .80, and the P value is .4548. This P value shows no significant difference between the two allocation schemes in terms of the perceived fairness in the allocation of the joint cost. Therefore, both the seventh and the eighth hypotheses (H(7) and H(8)) cannot be rejected. Thus it is concluded that the subjects in the experiment did not differ in terms of their perceived fairness of the two allocation schemes. Table 14 shows a minor difference between the fairness scores made by the managers under the two allocation schemes. As shown in table 14 for Period 13, the managers under both the N method and the S method felt that, on the average, the joint cost allocation was neither fair nor unfair (the sum of the two managers' fairness scores is 5.4667 under the N method and 5.7000 under the S method). Similarly, the level of disparity in the perceived

fairness between the two managers is not high under either allocation method (the absolute difference between the two managers' fairness scores is 1.3333 under the N method and 1.1000 under the S method).

The MANOCOVA model was also used to see whether knowledge of how the allocations were calculated made any difference in the subjects' perception of fairness. The Wilks's lambda statistic is .9397, the transformed F statistic is 1.76, and the P value is .1809. This P value is too high to reject the seventh and eighth hypotheses. Therefore, again the conclusion is drawn that the subjects did not differ in their perceptions of fairness of the two allocation methods. In table 14 for Period 19, the sums of the two managers' fairness scores are similar to those at Period 13 (5.6667 under the N method and 5.6000 under the S method), but the absolute difference between the two managers' fairness scores declined (1.0667 under the N method and .7333 under the S method). Based on these results it is inferred that knowledge of how the allocations were calculated led the two managers to narrow their level of disparity of perceived fairness, even though they still felt the allocation was neither fair nor unfair.

Design for Hypothesis 9

The ninth hypothesis examined whether there is any difference between the two allocation schemes in encouraging

the divisional managers to cooperate in using the joint copier. To measure the extent to which the managers are encouraged to use the joint copier, two proportions were calculated. The first is the proportion of "yes" answers to the question concerning whether they wish to continue using the joint copier. The second is the proportion of simultaneous "yes" answers by the two managers. Table 15 shows the percentage of "yes" responses under each method.

In order to test the ninth hypothesis, two t-tests were used. First, a t-test was used to examine whether there is any difference between the two allocation schemes in the proportion of the number of "yes" answers. The t-test shows no significant difference between the two allocation schemes ($t = -.9998$, $df = 118$, $P > .10$). The second t-test was used to test whether there is any difference between the two allocation methods in the proportion of the number of simultaneous "yes" answers. The second t-test also shows no significant difference between the two allocation schemes ($t = -1.2920$, $df = 58$, $P > .10$). With these results, the ninth hypothesis (H(9)) cannot be rejected and it is concluded that the two allocation schemes did not lead the subjects to differ in the degree of cooperation in using the joint copier.

Summary

This chapter presented the results of the

TABLE 15

THE PERCENTAGE OF "YES" RESPONSES

Response of		N method	S method
Disision 1 manager	Division 2 manager		
Y	Y	12 pairs	17 pairs
Y	N	1	5
N	Y	15	6
N	N	2	2
Number of Y		40	45
Total number of subjects		60	60
PY(1)		.6667	.7500
Number of YY		12	17
Total number of pairs of subjects		30	30
PYY(2)		.4000	.5667

(1) The proportion of the number of "yes" answers to the total number of answers.

(2) The proportion of the number of simultaneous "yes" answers by the Division 1 manager and the Division 2 manager to the total number of paired answers.

statistical tests for each statistical design described in Chapter III. The results show that the difference in allocation schemes made a statistically significant difference only in the Division 1 managers' pricing decisions. The results show no significant difference

between the two allocation schemes in leading the Division 2 managers to set prices that render net incomes closer to the optimal net income nor in the overall net income for the firm. The results also show no statistically significant difference in the perceived fairness of the allocations nor in the degree of cooperation among the managers using the joint copier. Among the nine hypotheses tested in this study only the first and the fourth hypotheses were rejected. In the next chapter the implications of these results will be explored.

CHAPTER V

IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Introduction

This chapter discusses the implications of this research, in light of its findings. The chapter also includes a discussion of the limitations of the experimental approach taken. Finally, suggestions are provided for further empirical research on the effects of joint cost allocation on decision making.

Implications Of This Study

This experimental study is the first to provide empirical evidence on the relative usefulness of two joint cost allocation methods. The net realizable and the Shapley value allocation schemes were compared in the context of a decision-making situation. The basic intent of the study was to determine if one of the methods was better than the other in the sense of whether one method led to better decisions and more cooperation.

This study addressed four research questions. The

first question concerned the difference, if any, between the effects of the two allocation schemes on managers' pricing decisions. The first three hypotheses were directed at this research question. The statistical tests only show a significant difference between the two allocation methods in affecting the Division 1 managers' pricing decisions. They do not indicate significant differences in the Division 2 managers' pricing decisions nor in the firm's overall profit position. Since the firm's overall profit position is not affected by the difference in allocation methods, the firm's central manager may wish to select between the two based on other factors (e.g., which is the cheaper method and/or which is easier to adopt).

For this research question, the statistical tests provide anomolous results; that is, the difference in allocation schemes made a significant difference in the Division 1 managers' pricing decisions, but it did not make a significant difference in the Division 2 managers' pricing decisions. It is unclear why these different results occur. Possibly, the subjects in the two groups differed in some unknown way. However, assuming that these results are valid, table 10 shows that the S method led the Division 1 managers to poor pricing decisions. Hence, the N method appears preferable.

The second research question asked whether managers could better adapt to a change in demand with one method

versus the other. The fourth, fifth, and sixth hypotheses were formulated to examine this research question. The statistical tests provide results similar to those for research question 1. Again, no significant difference exists between the two methods in their effect on the firm's overall net income. Therefore, again the firm's central manager may be advised to adopt either of these two schemes based on other factors. Again, different results are shown in the effect of allocation methods on the divisional managers' pricing decisions; that is, the allocation schemes led to a significant difference in the Division 1 managers' pricing decisions, but it did not make a significant difference in the Division 2 managers' pricing decisions. As shown in table 12, the Division 1 managers under the S method again made poor pricing decisions when they encountered a changed demand function. Therefore, based on the same consideration as in research question 1, the N method seems preferable.

A potential explanation for the fact that the allocations affected the Division 1 managers but not the Division 2 managers was examined. At the beginning of Period 14 in the experiment, the instructions given to the participants (see page 124) may have been interpreted to mean that prices should go up. It is true that the optimal action for the Division 2 managers was to raise the price, but for Division 1 the optimal action was to lower the

price. To see if this had an effect, the direction of each participant's price change for Period 14 was examined. The experimental results show that about half of the Division 1 managers set a higher price in Period 14, but there is no significant difference between the N method group and the S method group (15 subjects under the N method and 17 under the S method set a higher price in Period 14). In addition, the direction of the price changes was not much different between the Division 1 managers and the Division 2 managers (9 Division 2 managers under the N method and 15 under the S method raised the price).

The third research question addressed the issue of the perceived fairness of the two allocation schemes. The seventh and eighth hypotheses were used to examine this research question. The results of the test show no significant difference between the two allocation schemes in terms of perceived fairness. As shown in table 14 the two allocation methods are about the same in the level of fairness perceived by the managers. These results do not support the argument that the Shapley value allocation scheme can be viewed as providing for a more equitable sharing of cost externalities arising from the jointness of production.

At the end of Period 13 and Period 19 of the experiment, the subjects were asked to specify the factors that they considered in measuring the level of fairness of

the allocation. As shown in table 16, the majority of the subjects in this study thought that the joint cost should

TABLE 16

FACTORS INFLUENCING FAIRNESS PERCEPTIONS

Factors	N method				S method			
	Division 1		Division 2		Division 1		Division 2	
	P13*	P19*	P13*	P19*	P13*	P19*	P13*	P19*
(1) Number of copies sold	15	18	17	15	18	19	15	16
(2) Net income	14	10	9	12	7	9	13	13
(3) Cost savings	1	2	4	3	5	2	2	1

* P13 stands for Period 13 and P19, for Period 19.

(1) The joint cost should be allocated based on how much a division uses the common copier.

(2) The joint cost should be allocated based on how much net income a division earns.

(3) The joint cost should be allocated such that the cost savings from the jointness are divided evenly between the two divisions.

be allocated based on how much a division uses the common copier. Therefore, they support the minimum resource allocation scheme (or the activity level allocation scheme). About one third of the subjects thought that the joint cost should be allocated based on how much net income a division earns. Therefore, they support the net realizable value allocation scheme. Only a few subjects thought that the

joint cost should be allocated such that the cost savings from the jointness are divided evenly between the two divisions. Therefore, the Shapley value allocation scheme did not receive much support from the subjects in this study. This implies that the Shapley value allocation scheme had less "common sense" appeal to the relatively naive subjects in this study.

The last research question concerned the difference between the two allocation schemes in encouraging the divisional managers to use a common facility. The ninth hypothesis was directed at this research question. The results of the tests show no significant difference between the two allocation methods even though the managers under the S method were more encouraged to use the common copier (in table 15, PY under the S method is .7500 which is greater than .6667 under the N method; PYY under the S method is .5667 which is larger than .4000 under the N method).

At the end of the experiment the subjects were asked to list the factors which led to their decision of whether they would continue to use the joint copier. About half of the subjects (56 subjects out of 120) answered that the cost savings (or negative cost savings when they answered "no") led them to make their decision. The other half of the subjects (60 subjects out of 120) answered that the amount of net income led them to decide whether to

continue sharing the copier. If they earned less net income at the end of Period 19 (when they jointly used a common copier), they decided not to share the common copier.

It would be possible that subjects may not want to share the copier even though sharing the copier renders cost savings. Because even in a situation where they get savings in the copier rental cost, they might earn a smaller amount of net income than when they used a separate copier independently. This situation could occur depending on the demand and cost functions and on how the managers set their prices. Therefore, it is hard to differentiate the effect of a cost allocation scheme from poor pricing decisions on the managers' decision whether to continue using the joint copier.

Among the remaining four subjects, three did not want to use the joint copier because they did not like the unpredictable costs and net incomes in the joint use situation. One subject indicated "the number of copies sold" as the factor that affected his decision, but he seems to have misunderstood the question.

An interesting finding in this question is that no subject indicated "fairness" per se as a factor that affected his or her decision. Judging from the responses of the subjects in this study, "fairness", as such, is not related to the managers' decision whether to continue using the joint copier. Instead the decision was much more

related to economic considerations; such as the existence of cost savings or higher net income.

At the end of the experiment the subjects were asked what factors they considered when they selected selling prices. Most of the subjects (94 subjects out of 120) indicated they concentrated on net income and a few subjects indicated they followed sales or costs (13 subjects for sales and 13 subjects for costs). These responses indicate that most of the subjects were concerned with the amount of net income that they earned, which makes sense since they were evaluated based on how much net income they earn. This fact indirectly confirms that the performance evaluation system and the monetary reward offered to the subjects effectively worked to encourage them to do well in performing the experiment.

In the experiment, allocated costs, per se, were not considered by the subjects when setting prices. But, for those that concentrated on net income, there was an indirect effect since the allocated cost was subtracted from sales revenue to yield net income. Hence it was still possible for the allocation to have a differing effect on the subject's pricing decisions.

While examining the raw data obtained from the experiment, three outliers (i.e., three subjects who set prices and answered the questions in an unusual or apparently careless way) were found. To determine whether

these three outliers had a significant effect on the results of this study, the statistical tests were repeated for the data set without these outliers. The results, however, indicated no difference from the results with the outliers. Therefore, the results without the outliers are not reported in this study.

Limitations Of This Study

This study used a laboratory experiment with student subjects. In this type of study serious questions may be raised concerning the validity of the results of this experiment in the real world. It may be asked (1) if the laboratory can approximate complex reality and (2) if student subjects can represent actual decision makers in the real world.

The first question is about the research setting and the research task. The research setting and task in this study were hypothetical. Cost and demand functions in this study were arbitrarily constructed. Therefore, the findings and conclusions of this study will be valid only to the extent that the functions are realistic. some limitations are inherent in the assumptions in the hypothetical setting. For example, the participants were told to maximize short-run profit; the decentralized divisions use a copier jointly; and yet the market is clearly segmented for the divisions which use the same

copier. These assumptions decrease the experimental reality.

The underlying reasons for the concern raised in the second question are those given by Birnberg and Nath (1968, p. 40) who state:

> The analogous real world group is likely to differ from the student subjects in two ways:
> 1. A lack of common skills and experience between the two groups.
> 2. A lack of comparable basic personality traits in both the subjects and the relevant non-experimental reference groups.

Several accounting studies which have focused on decision making have found considerable similarities in the decisions and the underlying information-processing behavior of student and non-student groups. For example, Dyckman (1966) found that students and businessmen made very similar evaluations of two experimental firms and that their decisions appeared to be based on similar factors. Mock (1969), Hofstedt (1972), and Dickhaut (1973) all found essentially no differences between students and businessmen in their experimental tasks. These findings provide some support for the use of students in this study. But, as Birnberg and Nath stated, the subjects in this study do lack skills and experience in business. They may also have different personality traits. For example, they may react differently in stressful situations. Students may strive to optimize rather than satisfice despite additional stress. In contrast, real managers may avoid stress by trying to

satisfice. These differences may result in findings which would not be representative of outcome in an actual business situation.

Other limitations are technical in nature. That is, there were budget and time constraints in conducting the experiments. If each experiment were conducted over a span of several weeks, subjects would have had more time to contemplate the fairness, or lack thereof, of the allocation methods. Consequently, different results might be obtained in such a situation. Some of these limitations could be overcome through further research.

Suggestions For Further Research

Because of the unusual results obtained for research questions one and two, a replication of this study would be useful to determine if the results herein are confirmed with a different group of subjects and with different setting and/or situations. In this study the reward system was based on divisional income, i.e., each subject was evaluated and rewarded based on how much his or her division earned. But, if the reward system were based on firm-wide income, that is, if it were based on how much the Division 1 and the Division 2 managers earn together, the results of the study might have differed. A replication of this study using a field experiment might also provide more generalizable results on the effects of the allocation

scheme on managers' pricing decisions. If managers in a real business could be used as subjects in the experiment, the external validity of the results would increase. If both students and managers could be used as subjects, the results of the student subjects and those of the manager subjects could be compared and some conclusions could be drawn on the student surrogate problem in this context.

This study selected the net realizable value allocation and the Shapley value allocation scheme because they seemed to be the most widely used or discussed schemes. There are other allocation schemes that could be compared. As introduced in Chapter I, there are also the minimum resource allocation scheme (or the activity level allocation scheme), the bargaining theory allocation scheme, and the Moriarity allocation scheme. Especially because the minimum resource allocation was perceived as being the most "common sense" method (as shown by the responses of the subjects in this study) it should be a candidate for further study.

As mentioned in Chapter I, Roth and Verrecchia (1979) suggest that the Shapley value allocation may be viewed as a costless surrogate for the bargaining process, while Boatsman, Hansen, and Kimbrell (1981) maintain that the minimum resource allocation scheme is a suitable surrogate for the bargaining process. These conflicting normative arguments might be resolved by empirically comparing these two allocations and a pure bargaining

allocation. From a different perspective it has been suggested that allocations are not necessary. Hence it would also be useful to compare the various allocation schemes with no allocation in a decision situation.

The replications and extentions mentioned above should help to provide further empirical evidence on the effect of various allocation procedures on managers' decision behavior. The present study has provided a starting point by providing empirical evidence on the relative usefulness of two allocation procedures. It is hoped that this study will interest other researchers to join the quest for further information on the effects of allocations.

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APPENDIX A

CALCULATION OF THE OPTIMAL PRICES AND NET INCOMES

Given the demand functions (on page 33) and the cost functions (on pages 35-36), it is possible to calculate the optimal price and net income using the traditional microeconomic profit maximization model by equating marginal revenue and marginal cost. In the computation of the optimal price and net income the following notation is useful:

X_i = quantity sold in number of copies by Division i (i=1,2)

X_i^* = optimal quantity that renders the maximum net income

X = combined quantity sold by Division 1 and Division 2

P_i = selling price in dollars set by the manager of Division i

P_i^* = optimal price that renders the maximum net income of Division i

TR_i = total revenue of Division i

TC_i = total cost of Division i

TC = combined total cost of Division 1 and Division 2

MR_i = marginal revenue of Division i

MC_i = marginal cost of Division i

MC = marginal cost of Division 1 and Division 2 combined

CM_i^* = optimal contribution margin of Division i

CM^* = optimal contribution margin of Division 1 and Division 2 combined

FC = combined fixed cost of Division 1 and Division 2

NI_i^* = optimal net income of Division i

NI^* = optimal overall net income

IFC_i = independent fixed cost of Division i

JVC_i = joint variable cost of Division i

JVC = joint variable cost of Division 1 and Division 2 combined

JFC_i = joint fixed cost of Division i

JFC = joint fixed cost of Division 1 and Division 2 combined

JC_i = joint cost of Division i

JC = joint cost of Division 1 and Division 2 combined

CR_i = independent copier rental cost of Division i

The optimal price and net income of Division 1 for Periods 1-8 are computed as follows:

$$X_1 = 170/P_1^{2.5}$$

$$P_1 = 170^{1/2.5}/X_1^{1/2.5}$$

$$TR_1 = P_1 \times X_1$$

$$= (170^{1/2.5}/X_1^{1/2.5}) \times X_1$$

$$= 170^{1/2.5} \times X^{1.5/2.5}$$

$$MR_1 = dTR_1/dX_1 = 170^{1/2.5} \times (15/25) \times X_1^{-1/2.5}$$

$$TC_1 = 3,415 + .0306\ X_1 \quad \text{if} \quad 0 < X_1 \leq 100,000$$

$TC_1 = 2{,}495 + .0398\,X_1$ if $100{,}000 < X_1 \leq 250{,}000$

$TC_1 = 2{,}695 + .0390\,X_1$ if $250{,}000 < X_1$

$MC_1 = dTC_1/dX_1 = .0306$ if $0 < X_1 \leq 100{,}000$

$MC_1 = .0398$ if $100{,}000 < X_1 \leq 250{,}000$

$MC_1 = .0390$ if $250{,}000 < X_1$

(1) if $0 < X_1 \leq 100{,}000$

$MR_1 = MC_1$

$170^{1/2.5} X (15/25) \times X_1^{1/2.5} = .0306$

$X_1^{1/2.5} = 170^{1/2.5}/(.0306 \times (25/15))$

$X_1 = 170/(.0306 \times (25/15))^{2.5} = 289{,}417$

This X_1 value does not meet the condition $(0 < X_1 \leq 100{,}000)$. Hence, this is not the optimal solution.

(2) if $100{,}000 < X_1 \leq 250{,}000$

$MR_1 = MC_1$

$X_1 = 170/(.0398 \times (25/15))^{2.5} = 150{,}010$

This X_1 value meets the condition $(100{,}000 < X_1 \leq 250{,}000)$.

$X_1^* = 150{,}010$

$P_1^* = .0398 \times (25/15) = .066333$

$NI_1^* = (.066333 - .0398) \times 150{,}010 - 2{,}495 = 1{,}485.25$

(3) if $250{,}000 < X_1$

$MR_1 = MC_1$

$X_1 = 170/(.0390 \times (25/15))^{2.5} = 157{,}821$

This X_1 value does not meet the condition $(250{,}000 < X_1)$. Hence, this is not the optimal solution.

The optimal price and net income of Division 2 for

Periods 1-8 are calculated in the same manner.

It is also possible to calculate the optimal prices and net incomes for Periods 9-13 (in which the two divisional managers use a common copier). First, the optimal prices for Division 1 and Division 2, and the optimal overall net income are calculated by equating the marginal revenue of each division with the marginal cost of Division 1 and Division 2 combined (in this study this marginal cost is the same as each division's marginal cost). The combined cost function for Periods 9-13 is as follows:

$TC = 8{,}700 + .0306\,X$ if $0 < X \leq 300{,}000$

$TC = 6{,}300 + .0386\,X$ if $300{,}000 < X \leq 700{,}000$

$TC = 9{,}100 + .0346\,X$ if $700{,}000 < X$

The demand functions faced by the divisions are the same as those faced when divisions used independent copiers. The optimal prices and overall net income for Periods 9-13 are computed as follows:

(1) if $0 < X \leq 300{,}000$

$MR_1 = MC$

$X_1 = 170/(.0306x(25/15))^{2.5} = 289{,}417$

$MR_2 = MC$

$X_2 = 500/(.0306x(22/12))^{2.2} = 282{,}652$

$X = X_1 + X_2 = 572{,}069$

This X value does not meet the condition ($0 < X \leq 300{,}000$). Hence, this is not the optimal solution.

(2) if $300,000 < X \leq 700,000$

$MR_1 = MC$

$X_1 = 170/(.0386x(25/15))^{2.5} = 161,942$

$MR_2 = MC$

$X_2 = 500/(.0386x(22/12))^{2.2} = 169,569$

$X = X_1 + X_2 = 331,511$

This X value meets the condition ($300,000 < X \leq 700,000$).

$X_1^* = 161,942$

$X_2^* = 169,569$

$P_1^* = .0386x(25/15) = .064333$

$CM_1^* = (.064333 - .0386)x161,942 = 4,167.25$

$P_2^* = .0386x(22/12) = .070767$

$CM_2^* = (.070767 - .0386)x169,569 = 5,454.47$

$CM^* = CM_1^* + CM_2^* = 9,621.72$

$NI^* = CM^* - FC = 9,621.72 - 6,300 = 3,321.72$

(3) if $700,000 < X$

$MR_1 = MC$

$X_1 = 170/(.0346x(25/15))^{2.5} = 212,881$

$MR_2 = MC$

$X_2 = 500/(.0346x(22/12))^{2.2} = 215,711$

$X = X_1 + X_2 = 428,592$

This X value does not meet the condition ($700,000 < X$).

Hence, this is not the optimal solution.

The optimal net income of each division can be determined in the combined quantity range of $300,000 < X \leq 700,000$ as follows:

(1) Under the N method

$JFC = 5,600 - 300,000 \times .0080 = 3,200$

$JFC_1 = JFC \times (CM_1^*/CM^*)$

$= 3,200 \times (4,167.25/9,621.72) = 1,385.95$

$JFC_2 = JFC \times (CM_2^*/CM^*)$

$= 3,200 \times (5,454.47/9,621.72) = 1,814.05$

$NI_1^* = CM_1^* - (IFC_1 + JFC_1)$

$= 4,167.25 - (1,400 + 1,385.95) = 1,381.30$

$NI_2^* = CM_2^* - (IFC_2 + JFC_2)$

$= 5,454.47 - (1,700 + 1,814.05) = 1,940.42$

(2) Under the S method

$JVC_1 = .0080\ X_1 = .0080 \times 161,942 = 1,295.54$

$JVC_2 = .0080\ X_2 = .0080 \times 169,569 = 1,356.55$

$JVC = JVC_1 + JVC_2$

$= 1,295.54 + 1,356.55 = 2,652.09$

$JFC = 5,600 - 300,000 \times .0080 = 3,200$

$JC = JVC + JFC$

$= 2,652.09 + 3,200 = 5,852.09$

$CR_1 = 2,015 + (161,942 - 100,000) \times .0092 = 2,584.87$

$CR_2 = 3,885$

$JC_1 = .5 \times (CR_1 + (JC - CR_2))$

$= .5 \times (2,584.87 + (5,852.09 - 3,885)) = 2,275.98$

$JC_2 = .5 \times ((JC - CR_1) + CR_2)$

$= .5 \times ((5,852.09 - 2,584.87) + 3,885) = 3,576.11$

$JFC_1 = JC_1 - JVC_1$

$= 2,275.98 - 1,295.54 = 980.44$

$$JFC_2 = JC_2 - JVC_2$$

$$= 3,576.11 - 1,356.55 = 2,219.56$$

$$NI_1^* = CM_1^* - (IFC_1 + JFC_1)$$

$$= 4,167.25 - (1,400 + 980.44) = 1,786.81$$

$$NI_2^* = CM_2^* - (IFC_2 + JFC_2)$$

$$= 5,454.47 - (1,700 + 2,219.56) = 1,534.91$$

The optimal prices and net incomes for Periods 14-19 are calculated in the same manner.

APPENDIX B

INSTRUCTIONS FOR THE EXPERIMENT

(first set of instructions)

1. Introduction

Good day. In this experiment you are to act as my employee. I have hired you to manage one of my copy shops. We rent a copier from the Xerox Corporation, rent shop space, have one part time employee and must incur costs for paper, utilities, copier fluid and so on. Some of these costs will be the same each period while others will vary depending on your volume of business. I am going to evaluate your performance on your ability to maximize short-run profits. For each time period (trial) of the experiment I am going to prepare an income statement based upon your performance. Because our business performs services only to order, we will not need to be concerned with inventories.

Because I own several small businesses, I cannot keep up with the competitive characteristics of the market place for each of them. I have hired you to do the best you can in the actual competitive market place in which your shop is located. I do know, and can tell you, that other

copy shops in the area tend to advertise their prices to the nearest tenth of a cent per copy (such as 2.6 cents per copy or 9.8 cents per copy). Your major task as the shop manager will be to establish a selling price per copy (to the nearest tenth of a cent) which will maximize our net income.

I realize that you probably don't have much experience in managing such a shop. Therefore, I will let you operate for four periods (trials) before beginning to measure your performance. During this trial period you should attempt to learn as much as you can about how volume is affected by the selling price you specify and about how costs vary with volume. After the four trials periods are over, I will begin to record your performance.

As promised earlier, I will give a $50 bonus to the manager who earns the greatest profit in the same situation that you face. That is, there will be a total of thirty persons acting as the manager of this same shop. The person who does best will receive the bonus. By the way, the other person in this experiment is <u>not</u> competing with you. He or she is in a slightly different business environment. It is possible that both you and the other person here today could each receive a $50 bonus if each of you does the best jobs relative to the other persons who will take each of your respective places.

Since you are competing with other students who will take your place, it is to your benefit to not to talk

with other persons about the process of this experiment. In addition, doing so may mislead people subsequently participating in this experiment. I have prepared many different experimental environments, and therefore actions which are appropriate for your environment could be disastrous in one of the other environments.

2. Task

You are to now set a selling price per copy (to the nearest tenth of a cent for the next operating period). After you do so, I will give you an income statement which summarizes the operating results for the period. Your first price should be set using "common sense": i.e., what you know about the general market for copies.

Are there any questions?

(First eight trials are conducted.)

Division manager

Name _____

Periods	Selling Price	Net Income
1	_____¢	$_____
2	_____¢	$_____
3	_____¢	$_____
4	_____¢	$_____
5	_____¢	$_____
6	_____¢	$_____
7	_____¢	$_____
8	_____¢	$_____
9	_____¢	$_____
10	_____¢	$_____
11	_____¢	$_____
12	_____¢	$_____
13	_____¢	$_____
14	_____¢	$_____
15	_____¢	$_____
16	_____¢	$_____
17	_____¢	$_____
18	_____¢	$_____
19	_____¢	$_____

(second set of instructions)

I have just been approached by a salesman who has convinced me that we can save some money if I combine the production operations of your copy shop with those of the other manager who is here today. Therefore, for the next several periods I will combine the production operations, and you and the other manager will jointly use a copier. Your market conditions (your competition) will not change. However, you will notice a change in your operating costs. Again, remember that the other manager here today operates in a slightly different economic environment than you do, thus you are not competing with him or her.

(Five trials are conducted.)

(third set of instructions)

(for the net realizable value method)

Division manager

Name _____

For the previous five periods I divided the cost to rent the copier between you and the other manager in proportion to the amount of income you each earned.

An example of the calculation of your charge for using the copier and some other related information is provided with this sheet. Referring to this information, please answer the following questions.

1. How do you feel about the way in which your share of the cost for using the copier was determined?
   (1) The computation is very unfair.
   (2) The computation is a little unfair.
   (3) The computation is moderately fair.
   (4) The computation is very fair.

2. What factors influenced your response to question 1?

(third set of instructions)

(for the Shapley value method)

Division manager

Name _____

For the previous five periods I divided the cost to rent the copier between you and the other manager by calculating the total cost each of you would have incurred had you used the equipment you used in trials 1-8. The total savings from using the new copier were then split evenly between you and the other manager.

An example of the calculation of your charge for using the copier and some other related information is provided with this sheet. Referring to this information, please answer the following questions.

1. How do you feel about the way in which your share of the cost for using the copier was determined?
   (1) The computation is very unfair.
   (2) The computation is a little unfair.
   (3) The computation is moderately fair.
   (4) The computation is very fair.

2. What factors influenced your response to question 1?

(fourth set of instructions)

I have just learned that there has been a major economic change in the market place. The prices which you have been setting for the last several periods may no longer provide a satisfactory net profit. I suggest you consider changing your prices, for it may very well lead to a better level of profits than you would otherwise experience. Remember your goal is to maximize the profits we earn.

(Six trials are conducted.)

(fifth set of instructions)

Division manager

Name _____

For the next set of trials I will give you the choice to either return to using the copier you used in Periods 1-8 or to continue to share the copier which you have used with the other manager during Periods 9-19.

1. Do you wish to continue sharing the copier used in trials 9-19?
   (1) Yes.
   (2) No.

2. What factors led to your decision in 1?

3. I explained to you earlier how your charge for the use of the new copier was calculated. Now that you have had some experience in setting prices while knowing the way the copier costs were charged to you, how do you feel about the way in which your share of the cost for using the copier was determined?
   (1) The computation is very unfair.
   (2) The computation is a little unfair.
   (3) The computation is moderately fair.

(4) The computation is very fair.

4. What factors influenced your response to question 3?

5. Would you explain briefly what factors you considered when selecting your selling prices?

Name _____

1. I need some information about you in analyzing the data obtained from this game. Please answer the questions below. I will use the information for data analysis purposes only.
   (1) What is your classification (e.g., junior, senior, etc.)?
   (2) What is your major (e.g., accounting, management, etc.)?
   (3) Have you ever worked in business (part-time or full-time)? If yes, in what business, in what position, and how long?

2. In April I will be able to determine the $50 winner. You might be the winner. Will you still have the same telephone number in April that you gave me earlier? If not, please give me a permanent telephone number or address through which you can be reached.

   Telephone # _____

   Address _____

   _____

3. If you wish to get a summary of the general results of this game, please give an address at which you can be reached in April.

Address _____

_____

APPENDIX C

COMPUTER PROGRAM FOR MAKING THE INCOME STATEMENTS
(INDEPENDENT USE OF THE COPIER)

```
      REAL P1,P2,X1,X2,TR1,TR2,FC11,FC12,FC13,FC14,FC21,FC22,FC23,
     A     FC24,UVC1,UVC2,VC1,VC2,TC1,TC2,NI1,NI2,CR1,CR2,R(2),
     B     UVC11,UVC12,UVC21,UVC22,E1,E2,S1,S2,M1,M2
      DOUBLE PRECISION D
      DATA FC11,FC12,FC13,FC14,FC21,FC22,FC23,FC24/2015.,500.,
     A     600.,300.,3885.,600.,700.,400./
      DATA UVC11,UVC12,UVC21,UVC22/.0092,.0084,.0087,.0060/
      DATA UVC1,UVC2/.0306,.0306/
      D=999999.D0
      DO 5 I=1,8
      CALL GGNML(D,2,R)
      READ(5,*) P1,P2
      X1=170/P1**2.5
      X2=500/P2**2.2
      M1=0.0
      M2=0.0
      S1=.00137*X1
      S2=.00075*X2
      E1=(R(1))*S1+M1
      E2=(R(2))*S2+M2
      X1=X1+E1
      X2=X2+E2
      TR1=P1*X1
      TR2=P2*X2
      VC1=UVC1*X1
      VC2=UVC2*X2
      IF (X1 .LE. 100000.) GO TO 1000
      IF (X1 .LE. 250000.) GO TO 1001
      CR1=FC11+150000.*UVC11+(X1-250000.)*UVC12
      GO TO 1002
1000  CR1=FC11
      GO TO 1002
1001  CR1=FC11+(X1-100000.)*UVC11
1002  IF (X2 .LE. 300000.) GO TO 2000
      IF (X2 .LE. 500000.) GO TO 2001
      CR2=FC21+200000.*UVC21+(X2-500000.)*UVC22
      GO TO 2002
2000  CR2=FC21
      GO TO 2002
2001  CR2=FC21+(X2-300000.)*UVC21
```

```
2002 TC1=CR1+FC12+FC13+FC14+VC1
     TC2=CR2+FC22+FC23+FC24+VC2
     NI1=TR1-TC1
     NI2=TR2-TC2
     N=I
     WRITE(6,10) N
  10 FORMAT(1X,'MONTHLY INCOME STATEMENT OF DIVISION 1',
    A       5X,'(PERIOD',1X,I2,')'///)
     WRITE(6,11)
  11 FORMAT(1X,'REVENUE:')
     WRITE(6,12)  X1,P1,TR1
  12 FORMAT(4X,'SALES',10X,F8.0,1X,'COPIES',1X,'*',1X,'$',
    A       F5.3,15X,'$',F10.2//)
     WRITE(6,13)
  13 FORMAT(1X,'EXPENSES:')
     WRITE(6,14)  CR1
  14 FORMAT(4X,'COPIER RENTAL',30X,'$',F8.2/)
     WRITE(6,15)  FC12
  15 FORMAT(4X,'SHOP RENTAL',33X,F8.2/)
     WRITE(6,16)  FC13
  16 FORMAT(4X,'SALARY',38X,F8.2/)
     WRITE(6,17)  FC14
  17 FORMAT(4X,'UTILITIES',35X,F8.2/)
     WRITE(6,18)  X1,UVC1,VC1,TC1
  18 FORMAT(4X,'MATERIALS',6X,F8.0,1X,'COPIES',1X,'*',1X,'$',
    A       F6.4,4X,F8.2,3X,F10.2//)
     WRITE(6,19)  NI1
  19 FORMAT(1X,'NET INCOME',47X,'$',F10.2//////)
     WRITE(6,20) N
  20 FORMAT(1X,'MONTHLY INCOME STATEMENT OF DIVISION 2',
    A       5X,'(PERIOD',1X,I2,')'///)
     WRITE(6,11)
     WRITE(6,12)  X2,P2,TR2
     WRITE(6,13)
     WRITE(6,14)  CR2
     WRITE(6,15)  FC22
     WRITE(6,16)  FC23
     WRITE(6,17)  FC24
     WRITE(6,18)  X2,UVC2,VC2,TC2
     WRITE(6,19)  NI2
   5 CONTINUE
     STOP
     END
```

APPENDIX D

COMPUTER PROGRAM FOR MAKING THE INCOME STATEMENTS AND THE SUMMARY OF THE OPERATING RESULTS (JOINT USE OF THE COPIER) (Periods 9-13)

```
      REAL X1,X2,X,M1,M2,S1,S2,R(2),E1,E2,P1,P2,TR1,TR2,FC11,FC12,
     A     FC13,FC14,FC21,FC22,FC23,FC24,UVC1,UVC2,VC1,VC2,NIB1,
     B     NIB2,NIB,UVC11,UVC12,UVC21,UVC22,CR1,CR2,CR,JFC1,JFC2,
     C     JFC,JVC1,JVC2,JVC,JC1,JC2,JC,NRV1,NRV2,NRV,CS1,CS2,CS,
     D     X1P,X2P,NIB1P,NIB2P,TR,TR1P,TR2P,FC2,FC12P,FC22P,FC3,
     E     FC13P,FC23P,FC4,FC14P,FC24P,VC,VC1P,VC2P,NI,NI1P,NI2P,
     F     JC1P,JC2P,CR1P,CR2P,CS1P,CS2P,TC1,TC2,NI1,NI2
      DOUBLE PRECISION D
      DATA FC11,FC12,FC13,FC14,FC21,FC22,FC23,FC24/2015.,500.,
     A     600.,300.,3885.,600.,700.,400./
      DATA UVC11,UVC12,UVC21,UVC22/.0092,.0084,.0087,.0060/
      DATA UVC1,UVC2/.0306,.0306/
      D=999997.D0
      DO 5 I=1,5
      CALL GGNML(D,2,R)
      READ(5,*) P1,P2
      X1=170/P1**2.5
      X2=500/P2**2.2
      M1=0.0
      M2=0.0
      S1=.00137*X1
      S2=.00075*X2
      E1=(R(1))*S1+M1
      E2=(R(2))*S2+M2
      X1=X1+E1
      X2=X2+E2
      TR1=P1*X1
      TR2=P2*X2
      VC1=UVC1*X1
      VC2=UVC2*X2
      IF (X1 .LE. 100000) GO TO 1000
      IF (X1 .LE. 250000) GO TO 1001
      CR1=FC11+150000*UVC11+(X1-250000)*UVC12
      GO TO 1002
1000  CR1=FC11
      GO TO 1002
1001  CR1=FC11+(X1-100000)*UVC11
1002  IF (X2 .LE. 300000) GO TO 2000
      IF (X2 .LE. 500000) GO TO 2001
      CR2=FC21+200000*UVC21+(X2-500000)*UVC22
```

```
      GO TO 2002
 2000 CR2=FC21
      GO TO 2002
 2001 CR2=FC21+(X2-300000)*UVC21
 2002 X=X1+X2
      IF (X .LE. 300000.) GO TO 3000
      IF (X .LE. 700000.) GO TO 3001
      JFC=5600+400000*.0080-700000*.0040
      JVC1=.0040*X1
      JVC2=.0040*X2
      GO TO 3002
 3000 JFC=5600
      JVC1=0.
      JVC2=0.
      GO TO 3002
 3001 JFC=5600-300000*.0080
      JVC1=.0080*X1
      JVC2=.0080*X2
 3002 JVC=JVC1+JVC2
      JC=JFC+JVC
      NRV1=TR1-JVC1-VC1
      NRV2=TR2-JVC2-VC2
      NRV=NRV1+NRV2
C *****
C  NET REALIZABLE VALUE METHOD
      IF (NRV .EQ. 0.) GO TO 100
      JFC1=JFC*NRV1/NRV
      JFC2=JFC*NRV2/NRV
      GO TO 500
  100 JFC1=JFC*.5
      JFC2=JFC*.5
  500 JC1=JVC1+JFC1
      JC2=JVC2+JFC2
C *****
C  SHAPLEY VALUE METHOD
C     JC1=.5*(CR1+(JC-CR2))
C     JC2=.5*((JC-CR1)+CR2)
C *****
      TC1=JC1+(FC12+FC13+FC14+VC1)
      TC2=JC2+(FC22+FC23+FC24+VC2)
      NI1=TR1-TC1
      NI2=TR2-TC2
      CR=CR1+CR2
      CS=CR-JC
      CS1=CR1-JC1
      CS2=CR2-JC2
      NIB1=TR1-(FC12+FC13+FC14+VC1)
      NIB2=TR2-(FC22+FC23+FC24+VC2)
      NIB=NIB1+NIB2
      TR=TR1+TR2
```

```
      FC2=FC12+FC22
      FC3=FC13+FC23
      FC4=FC14+FC24
      VC=VC1+VC2
      NI=NI1+NI2
      X1P=100*X1/X
      X2P=100*X2/X
      NIB1P=100*NIB1/NIB
      NIB2P=100*NIB2/NIB
      JC1P=100*JC1/JC
      JC2P=100*JC2/JC
      TR1P=100*TR1/TR
      TR2P=100*TR2/TR
      FC12P=100*FC12/FC2
      FC22P=100*FC22/FC2
      FC13P=100*FC13/FC3
      FC23P=100*FC23/FC3
      FC14P=100*FC14/FC4
      FC24P=100*FC24/FC4
      VC1P=100*VC1/VC
      VC2P=100*VC2/VC
      NI1P=100*NI1/NI
      NI2P=100*NI2/NI
      CR1P=100*CR1/CR
      CR2P=100*CR2/CR
      CS1P=100*CS1/CS
      CS2P=100*CS2/CS
      N=I+8
      WRITE(6,10) N
   10 FORMAT(1X,'MONTHLY INCOME STATEMENT OF DIVISION 1',
     A       5X,'(PERIOD',1X,I2,')'///)
      WRITE(6,11)
   11 FORMAT(1X,'REVENUE:')
      WRITE(6,12) X1,P1,TR1
   12 FORMAT(4X,'SALES',10X,F8.0,1X,'COPIES',1X,'@',1X,'$',
     A       F5.3,15X,'$',F10.2//)
      WRITE(6,13)
   13 FORMAT(1X,'EXPENSES:')
      WRITE(6,14) JC1
   14 FORMAT(4X,'YOUR SHARE OF COPIER RENTAL',16X,'$',F8.2/)
      WRITE(6,15) FC12
   15 FORMAT(4X,'SHOP RENTAL',33X,F8.2/)
      WRITE(6,16) FC13
   16 FORMAT(4X,'SALARY',38X,F8.2/)
      WRITE(6,17) FC14
   17 FORMAT(4X,'UTILITIES',35X,F8.2/)
      WRITE(6,18) X1,UVC1,VC1,TC1
   18 FORMAT(4X,'MATERIALS',6X,F8.0,1X,'COPIES',1X,'@',1X,'$',
     A       F6.4,4X,F8.2,3X,F10.2//)
      WRITE(6,19) NI1
   19 FORMAT(1X,'NET INCOME',47X,'$',F10.2//////)
```

```
      IF (I .NE. 5) GO TO 210
      WRITE(6,230) N
  230 FORMAT(4X,'SUMMARY OF THE OPERATING RESULTS FOR THE',
     A       1X,'TWO DIVISIONS FOR PERIOD',1X,I2///)
      WRITE(6,191)
  191 FORMAT(23X,'TOTAL',7X,'DIVISION 1',12X,'DIVISION 2'/)
      WRITE(6,192)
  192 FORMAT(1X,'1. COPIER RENTAL')
      WRITE(6,193) JC,JC1,JC1P,JC2,JC2P
  193 FORMAT(4X,'COST CHARGED TO:',1X,F8.2,2(3X,F8.2,
     A       1X,'(',F5.1,1X,'%',')')/)
      WRITE(6,195) TR,TR1,TR1P,TR2,TR2P
  195 FORMAT(1X,'2. SALES',12X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')')/)
      WRITE(6,196) FC2,FC12,FC12P,FC22,FC22P
  196 FORMAT(1X,'3. SHOP RENTAL',6X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')')/)
      WRITE(6,197) FC3,FC13,FC13P,FC23,FC23P
  197 FORMAT(1X,'4. SALARY',11X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')')/)
      WRITE(6,198) FC4,FC14,FC14P,FC24,FC24P
  198 FORMAT(1X,'5. UTILITIES',8X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')')/)
      WRITE(6,199) VC,VC1,VC1P,VC2,VC2P
  199 FORMAT(1X,'6. MATERIALS',8X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')')/)
      WRITE(6,200) NI,NI1,NI1P,NI2,NI2P
  200 FORMAT(1X,'7. NET INCOME',7X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')')/)
      WRITE(6,201)
  201 FORMAT(1X,'8. NUMBER OF COPIES')
      WRITE(6,202) X,X1,X1P,X2,X2P
  202 FORMAT(10X,'SOLD',7X,F8.0,2(3X,F8.0,1X,
     A       '(',F5.1,1X,'%',')')/)
      WRITE(6,203)
  203 FORMAT(1X,'9. NET INCOME BEFORE')
      WRITE(6,204)
  204 FORMAT(4X,'CHARGE FOR USE OF')
      WRITE(6,300) NIB,NIB1,NIB1P,NIB2,NIB2P
  300 FORMAT(10X,'COPIER',5X,F8.2,2(3X,F8.2,1X,
     A       '(',F5.1,1X,'%',')')/)
      WRITE(6,205)
  205 FORMAT(1X,'10. COST IF EACH')
      WRITE(6,206)
  206 FORMAT(5X,'DIVISION USED A')
      WRITE(6,207) CR,CR1,CR1P,CR2,CR2P
  207 FORMAT(5X,'SEPARATE COPIER',1X,F8.2,2(3X,F8.2,
     A       1X,'(',F5.1,1X,'%',')')/)
      WRITE(6,208)
  208 FORMAT(1X,'11. COST SAVINGS')
      WRITE(6,209)
```

```
209 FORMAT(5X,'(LINE 10 MINUS')
    WRITE(6,301) CS,CS1,CS1P,CS2,CS2P
301 FORMAT(6X,'LINE 1)',8X,F8.2,2(3X,F8.2,1X,
   A       '(',F6.1,'%',')')///////)
210 WRITE(6,20) N
 20 FORMAT(1X,'MONTHLY INCOME STATEMENT OF DIVISION 2',
   A       5X,'(PERIOD',1X,I2,')'///)
    WRITE(6,11)
    WRITE(6,12) X2,P2,TR2
    WRITE(6,13)
    WRITE(6,14) JC2
    WRITE(6,15) FC22
    WRITE(6,16) FC23
    WRITE(6,17) FC24
    WRITE(6,18) X2,UVC2,VC2,TC2
    WRITE(6,19) NI2
    IF (I .NE. 5) GO TO 220
    WRITE(6,230) N
    WRITE(6,191)
    WRITE(6,192)
    WRITE(6,193) JC,JC1,JC1P,JC2,JC2P
    WRITE(6,195) TR,TR1,TR1P,TR2,TR2P
    WRITE(6,196) FC2,FC12,FC12P,FC22,FC22P
    WRITE(6,197) FC3,FC13,FC13P,FC23,FC23P
    WRITE(6,198) FC4,FC14,FC14P,FC24,FC24P
    WRITE(6,199) VC, VC1,VC1P,VC2,VC2P
    WRITE(6,200) NI,NI1,NI1P,NI2,NI2P
    WRITE(6,201)
    WRITE(6,202) X,X1,X1P,X2,X2P
    WRITE(6,203)
    WRITE(6,204)
    WRITE(6,300) NIB,NIB1,NIB1P,NIB2,NIB2P
    WRITE(6,205)
    WRITE(6,206)
    WRITE(6,207) CR,CR1,CR1P,CR2,CR2P
    WRITE(6,208)
    WRITE(6,209)
    WRITE(6,301) CS,CS1,CS1P,CS2,CS2P
220 CONTINUE
  5 CONTINUE
    STOP
    END
```

(Periods 14-19)

```
      REAL X1,X2,X,M1,M2,S1,S2,R(2),E1,E2,P1,P2,TR1,TR2,FC11,FC12,
     A     FC13,FC14,FC21,FC22,FC23,FC24,UVC1,UVC2,VC1,VC2,NIB1,
     B     NIB2,NIB,UVC11,UVC12,UVC21,UVC22,CR1,CR2,CR,JFC1,JFC2,
     C     JFC,JVC1,JVC2,JVC,JC1,JC2,JC,NRV1,NRV2,NRV,CS1,CS2,CS,
     D     X1P,X2P,NIB1P,NIB2P,TR,TR1P,TR2P,FC2,FC12P,FC22P,FC3,
     E     FC13P,FC23P,FC4,FC14P,FC24P,VC,VC1P,VC2P,NI,NI1P,NI2P,
     F     JC1P,JC2P,CR1P,CR2P,CS1P,CS2P,TC1,TC2,NI1,NI2
      DOUBLE PRECISION D
      DATA FC11,FC12,FC13,FC14,FC21,FC22,FC23,FC24/2015.,500.,
     A     600.,300.,3885.,600.,700.,400./
      DATA UVC11,UVC12,UVC21,UVC22/.0092,.0084,.0087,.0060/
      DATA UVC1,UVC2/.0306,.0306/
      D=999995.DO
      DO 5 I=1,6
      CALL GGNML(D,2,R)
      READ(5,*) P1,P2
      X1=16/P1**3.3
      X2=1625/P2**1.8
      M1=0.0
      M2=0.0
      S1=.00210*X1
      S2=.00076*X2
      E1=(R(1))*S1+M1
      E2=(R(2))*S2+M2
      X1=X1+E1
      X2=X2+E2
      TR1=P1*X1
      TR2=P2*X2
      VC1=UVC1*X1
      VC2=UVC2*X2
      IF (X1 .LE. 100000) GO TO 1000
      IF (X1 .LE. 250000) GO TO 1001
      CR1=FC11+150000*UVC11+(X1-250000)*UVC12
      GO TO 1002
1000  CR1=FC11
      GO TO 1002
1001  CR1=FC11+(X1-100000)*UVC11
1002  IF (X2 .LE. 300000) GO TO 2000
      IF (X2 .LE. 500000) GO TO 2001
      CR2=FC21+200000*UVC21+(X2-500000)*UVC22
      GO TO 2002
2000  CR2=FC21
      GO TO 2002
2001  CR2=FC21+(X2-300000)*UVC21
2002  X=X1+X2
```

```
      IF (X .LE. 300000.) GO TO 3000
      IF (X .LE. 700000.) GO TO 3001
      JFC=5600+400000*.0080-700000*.0040
      JVC1=.0040*X1
      JVC2=.0040*X2
      GO TO 3002
 3000 JFC=5600
      JVC1=0.
      JVC2=0.
      GO TO 3002
 3001 JFC=5600-300000*.0080
      JVC1=.0080*X1
      JVC2=.0080*X2
 3002 JVC=JVC1+JVC2
      JC=JFC+JVC
      NRV1=TR1-JVC1-VC1
      NRV2=TR2-JVC2-VC2
      NRV=NRV1+NRV2
C *****
C  NET REALIZABLE VALUE METHOD
      IF (NRV .EQ. 0.) GO TO 100
      JFC1=JFC*NRV1/NRV
      JFC2=JFC*NRV2/NRV
      GO TO 500
  100 JFC1=JFC*.5
      JFC2=JFC*.5
  500 JC1=JVC1+JFC1
      JC2=JVC2+JFC2
C *****
C  SHAPLEY VALUE METHOD
C     JC1=.5*(CR1+(JC-CR2))
C     JC2=.5*((JC-CR1)+CR2)
C *****
      TC1=JC1+(FC12+FC13+FC14+VC1)
      TC2=JC2+(FC22+FC23+FC24+VC2)
      NI1=TR1-TC1
      NI2=TR2-TC2
      CR=CR1+CR2
      CS=CR-JC
      CS1=CR1-JC1
      CS2=CR2-JC2
      NIB1=TR1-(FC12+FC13+FC14+VC1)
      NIB2=TR2-(FC22+FC23+FC24+VC2)
      NIB=NIB1+NIB2
      TR=TR1+TR2
      FC2=FC12+FC22
      FC3=FC13+FC23
      FC4=FC14+FC24
      VC=VC1+VC2
      NI=NI1+NI2
```

```
      X1P=100*X1/X
      X2P=100*X2/X
      NIB1P=100*NIB1/NIB
      NIB2P=100*NIB2/NIB
      JC1P=100*JC1/JC
      JC2P=100*JC2/JC
      TR1P=100*TR1/TR
      TR2P=100*TR2/TR
      FC12P=100*FC12/FC2
      FC22P=100*FC22/FC2
      FC13P=100*FC13/FC3
      FC23P=100*FC23/FC3
      FC14P=100*FC14/FC4
      FC24P=100*FC24/FC4
      VC1P=100*VC1/VC
      VC2P=100*VC2/VC
      NI1P=100*NI1/NI
      NI2P=100*NI2/NI
      CR1P=100*CR1/CR
      CR2P=100*CR2/CR
      CS1P=100*CS1/CS
      CS2P=100*CS2/CS
      N=I+13
      WRITE(6,10) N
   10 FORMAT(1X,'MONTHLY INCOME STATEMENT OF DIVISION 1',
     A       5X,'(PERIOD',1X,I2,')'///)
      WRITE(6,11)
   11 FORMAT(1X,'REVENUE:')
      WRITE(6,12) X1,P1,TR1
   12 FORMAT(4X,'SALES',10X,F8.0,1X,'COPIES',1X,'*',1X,'$',
     A       F5.3,15X,'$',F10.2//)
      WRITE(6,13)
   13 FORMAT(1X,'EXPENSES:')
      WRITE(6,14) JC1
   14 FORMAT(4X,'YOUR SHARE OF COPIER RENTAL',16X,'$',F8.2/)
      WRITE(6,15) FC12
   15 FORMAT(4X,'SHOP RENTAL',33X,F8.2/)
      WRITE(6,16) FC13
   16 FORMAT(4X,'SALARY',38X,F8.2/)
      WRITE(6,17) FC14
   17 FORMAT(4X,'UTILITIES',35X,F8.2/)
      WRITE(6,18) X1,UVC1,VC1,TC1
   18 FORMAT(4X,'MATERIALS',6X,F8.0,1X,'COPIES',1X,'*',1X,'$',
     A       F6.4,4X,F8.2,3X,F10.2//)
      WRITE(6,19) NI1
   19 FORMAT(1X,'NET INCOME',47X,'$',F10.2//////)
      IF (I .NE. 6) GO TO 210
      WRITE(6,230) N
  230 FORMAT(4X,'SUMMARY OF THE OPERATING RESULTS FOR THE',
     A       1X,'TWO DIVISIONS FOR PERIOD',1X,I2///)
```

```
      WRITE(6,191)
  191 FORMAT(23X,'TOTAL',7X,'DIVISION 1',12X,'DIVISION 2')
      WRITE(6,192)
  192 FORMAT(1X,'1. COPIER RENTAL')
      WRITE(6,193) JC,JC1,JC1P,JC2,JC2P
  193 FORMAT(4X,'COST CHARGED TO:',1X,F8.2,2(3X,F8.2,
     A       1X,'(',F5.1,1X,'%',')'))
      WRITE(6,195) TR,TR1,TR1P,TR2,TR2P
  195 FORMAT(1X,'2. SALES',12X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')'))
      WRITE(6,196) FC2,FC12,FC12P,FC22,FC22P
  196 FORMAT(1X,'3. SHOP RENTAL',6X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')'))
      WRITE(6,197) FC3,FC13,FC13P,FC23,FC23P
  197 FORMAT(1X,'4. SALARY',11X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')'))
      WRITE(6,198) FC4,FC14,FC14P,FC24,FC24P
  198 FORMAT(1X,'5. UTILITIES',8X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')'))
      WRITE(6,199) VC,VC1,VC1P,VC2,VC2P
  199 FORMAT(1X,'6. MATERIALS',8X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')'))
      WRITE(6,200) NI,NI1,NI1P,NI2,NI2P
  200 FORMAT(1X,'7. NET INCOME',7X,F8.2,2(3X,F8.2,1X,'(',
     A       F5.1,1X,'%',')'))
      WRITE(6,201)
  201 FORMAT(1X,'8. NUMBER OF COPIES')
      WRITE(6,202) X,X1,X1P,X2,X2P
  202 FORMAT(10X,'SOLD',7X,F8.0,2(3X,F8.0,1X,
     A       '(',F5.1,1X,'%',')'))
      WRITE(6,203)
  203 FORMAT(1X,'9. NET INCOME BEFORE')
      WRITE(6,204)
  204 FORMAT(4X,'CHARGE FOR USE OF')
      WRITE(6,300) NIB,NIB1,NIB1P,NIB2,NIB2P
  300 FORMAT(10X,'COPIER',5X,F8.2,2(3X,F8.2,1X,
     A       '(',F5.1,1X,'%',')'))
      WRITE(6,205)
  205 FORMAT(1X,'10. COST IF EACH')
      WRITE(6,206)
  206 FORMAT(5X,'DIVISION USED A')
      WRITE(6,207) CR,CR1,CR1P,CR2,CR2P
  207 FORMAT(5X,'SEPARATE COPIER',1X,F8.2,2(3X,F8.2,
     A       1X,'(',F5.1,1X,'%',')'))
      WRITE(6,208)
  208 FORMAT(1X,'11. COST SAVINGS')
      WRITE(6,209)
  209 FORMAT(5X,'(LINE 10 MINUS')
      WRITE(6,301) CS,CS1,CS1P,CS2,CS2P
```

```
301 FORMAT(6X,'LINE 1)',8X,F8.2,2(3X,F8.2,1X,
   A       '(',F6.1,'%',')')///////)
210 WRITE(6,20) N
 20 FORMAT(1X,'MONTHLY INCOME STATEMENT OF DIVISION 2',
   A       5X,'(PERIOD',1X,I2,')'////)
    WRITE(6,11)
    WRITE(6,12) X2,P2,TR2
    WRITE(6,13)
    WRITE(6,14) JC2
    WRITE(6,15) FC22
    WRITE(6,16) FC23
    WRITE(6,17) FC24
    WRITE(6,18) X2,UVC2,VC2,TC2
    WRITE(6,19) NI2
    IF (I .NE. 6) GO TO 220
    WRITE(6,230) N
    WRITE(6,191)
    WRITE(6,192)
    WRITE(6,193) JC,JC1,JC1P,JC2,JC2P
    WRITE(6,195) TR,TR1,TR1P,TR2,TR2P
    WRITE(6,196) FC2,FC12,FC12P,FC22,FC22P
    WRITE(6,197) FC3,FC13,FC13P,FC23,FC23P
    WRITE(6,198) FC4,FC14,FC14P,FC24,FC24P
    WRITE(6,199) VC, VC1,VC1P,VC2,VC2P
    WRITE(6,200) NI,NI1,NI1P,NI2,NI2P
    WRITE(6,201)
    WRITE(6,202) X,X1,X1P,X2,X2P
    WRITE(6,203)
    WRITE(6,204)
    WRITE(6,300) NIB,NIB1,NIB1P,NIB2,NIB2P
    WRITE(6,205)
    WRITE(6,206)
    WRITE(6,207) CR,CR1,CR1P,CR2,CR2P
    WRITE(6,208)
    WRITE(6,209)
    WRITE(6,301) CS,CS1,CS1P,CS2,CS2P
220 CONTINUE
  5 CONTINUE
    STOP
    END
```

APPENDIX E

REQUEST FOR STUDENTS' PARTICIPATION IN THE EXPERIMENT

Earn $54 in one hour!

I have developed a simple game to help me gather information on managerial decision making. The data will be very helpful for my doctoral studies at O.U. I now need a large number of people to play this game and answer a few questions about the game.

The game requires one hour. I will pay $4 if you will participate. In addition, for each group of thirty students who participate, a prize of $50 will be awarded to the one member of the group who gets the best results in the game (ties, if any, will be broken by a suitable random process).

The game is not difficult. It requires you to attempt to set an optimal selling price for a service. Persons participating in the game so far, have found it interesting.

If you are willing to help me by participating in this game, would you please indicate below your name, telephone number and the days and times which would be most

convenient for you. I will call you to establish a specific, mutually convenient time for you to play the game.

Thank you.

Hai G. Park
O.U. Doctoral Candidate

This experiment relates to the subject matter of Accounting 2123. As such the School of Accounting encourages your participation. In recognition of the fact that we believe this will be a good learning experience for you, you will receive 5 points of extra credit to be added to your Accounting 2123 exam scores if you participate.

Shane Moriarity
Accounting 2123 Coordinator

Name _____ Telephone # _____
(When is the best time to call?
e.g., evenings?)

Please mark with an x times which would be convenient for you.

	Mon.	Tue.	Wed.	Thurs.	Fri
10:00 A.M.					
11:00					
12:00 Noon					
1:00 P.M.					
2:00					
3:00					
4:00					
5:00					
6:00					
7:00					
8:00					
9:00					