An Empirical Analysis of Share Contracting in Heterogeneous Groups

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Abstract

Sharing contracts divide a joint return among a group of contracting parties, and in this paper I study sharing rules devised under circumstances of group heterogeneity. Two categories of sharing contract are investigated. The first and perhaps more common category features sharing agreements formed prior to investments, and legal or reputational constraints on opportunistic renegotiations after investments are sunk. Contracts specifying equal sharing are predicted to occur with greater frequency in single speciality groups than multispeciality groups, and in smaller rather than larger groups. The analysis finds support for the prediction that equal sharing will be used with lower frequency in multispeciality groups, and for the prediction that equal sharing groups will be smaller than groups using productivity-weighted sharing rules. The second contract form studied here is from the incomplete contracting literature, and features allocation rules negotiated after individuals have sunk their investment in enhancing the joint return. Absent any repeat-relational contracting motives, the perfect equilibrium bargaining prediction implies allocation rules that are independent of investments. Analysis of sharing rules formed in a laboratory setting finds instead that ex post surplus shares are directly related to ex ante investment shares.

features sharing agreements formed prior to investments, and legal or reputational constraints on opportunistic renegotiations after investments are sunk. Existing empirical and case study research has focused on these ex ante sharing contracts. Ex ante sharing rules are shaped by investment issues such as promoting participation in the group enterprise, providing incentives, and sharing risk. An "equal shares" hypothesis is derived from the notion that as productivity differences increase in sharing groups, the use of productivity-indexed sharing rules will increase, while the use of rules specifying equal sharing will decrease.[3] I empirically evaluate this prediction in section II using sharing rule data on 1264 medical group practices. The data includes observations on both group type (single or multi speciality) and group size (number of physicians), and so provides a natural comparative static with which to test the equal shares hypothesis.

Multispeciality groups tend to include a mixture of primary care physicians with relatively low revenue products on the one hand, and surgeons and specialists with relatively high revenue products on the other. As a result multispeciality groups are confronted with substantially greater revenue product heterogeneity than single speciality groups. Thus one testable implication of the equal shares hypothesis is that rules specifying equal sharing will be less common in multispeciality groups, while productivity-indexed rules will be more common, because of the high participation constraints of surgeons and specialists relative to primary care physicians. This notion is strongly supported by the analysis, which finds for example that rules specifying equal sharing occur in 36 percent of all single-speciality groups (270/758), but only 4 percent of all multispeciality groups (20/506). Another testable implication of the equal shares hypothesis follows from Farrell and Scotchmer (1988), who predict that equal shares rules will inefficiently limit the size of groups (relative to sharing rules that include a weighted productivity component) because of revenue-product heterogeneity both within and

[3] In a similar vein Farrell and Scotchmer (1988) argue that if there are valuable complementarties that create an advantage to heterogeneous groups, equal surplus sharing will inefficiently constrain the feasibility of these groups.

across speciality fields. The analysis below finds substantial support for this group size prediction in multispeciality groups, while in contrast little support is found for the group size prediction in single speciality groups.

The second contract form studied here is from the incomplete contracting literature, and features "ex post" allocation rules negotiated after individuals have sunk their investment in enhancing the joint return.[4] Absent any repeat-relational contracting motives, the perfect equilibrium bargaining prediction implies ex post allocation rules that are independent of investments.[5] Empirical testing of ex post sharing agreement models is particularly difficult, and to my knowledge none have been done, because of the practical difficulty in controlling for ex post sharing agreements. Laboratory experimental methods can be used to control for the timing of sharing rule agreements and the specific protocol governing ex post sharing rule negotiations. Two testable hypotheses are derived in section HI. A perfect equilibrium bargaining hypothesis predicts ex post allocation rules independent of surplus-enhancing investments, while an equity-theoretic hypothesis predicts ex post sharing rules indexed to sunk investments when they are observable.

An analysis of the laboratory results finds support for both predictions when investments are unobservable, and some support for the equity-theoretic hypothesis when investments are observable. Support for the equity-theoretic hypothesis suggests a potentially important connection between investment heterogeneity and ex post sharing rule negotiations. An unanticipated result of this study is that ex post sharing agreements are commonly made up of a convex combination of equal and productivity-indexed shares under conditions of group heterogeneity. Such rules are consistent with

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[4] Pioneering work in on incomplete contracting and the firm includes Coase (1937), Simon (1951), Cyert and March (1963), Williamson (1975), Goldberg (1976), and Klein, Crawford, and Alchian (1978). More recent work in this area includes Grossman and Hart (1986), Tirole (1986), Fudenberg, Holmstrom, and Milgrom (1987), and Milgrom and Roberts (1987), Crawford (1988), and Hart and Moore (1988).

[5] See Macneil (1978) for a discussion of relational contracting.

the notion that allocations must accommodate conflict over competing fairness norms, and may reflect participation constraints that derive from utility over equitable distributions.

II. AN EMPIRICAL INVESTIGATION OF EX ANTE SHARING RULE AGREEMENTS IN MEDICAL GROUP PRACTICES

I begin by focusing attention on sharing contracts that feature "ex ante" allocation rules formed prior to investments, with legal or reputational constraints on opportunistic renegotiations after investments are sunk. Contracts with ex ante sharing rules are commonly observed in the field, as suggested by past empirical and case study research. Ex ante sharing rules are shaped by issues such as promoting participation in the group enterprise, providing incentives, and sharing risk. In this section I first discuss the nature of medical group practice, and establish the greater productive heterogeneity of multispeciality groups, and then test the heterogeneity hypothesis by comparing rule form across group type.

The Nature of Medical Group Practice

Why do some physicians (or professionals in general) join together into groups rather than operate solo? Farrell and Scotchmer (1988) argue very generally that partnerships arise because of scale economies. For example, a group practice may be in a better position to smooth the work load when business arrives in lumps. Fama and Jensen (1983), Carr and Mathewson (1990) and Kandel and Lazear (1992) argue for a mutual-monitoring advantage to professional groups. Mutual monitoring is a way of protecting group-specific reputational capital when information on the quality of professional services is more easily assessed by specialists of the same field. A second motive derives from Cheung's (1969) pioneering work on diversification in share contracts. Risk-averse professionals operating solo have asset holdings that are highly concentrated in their specialized human capital. These professionals have an incentive to join together in a sharing contract in order to diversify their individual asset holdings. Gilson and Mnookin (1985) have more recently applied this notion to law firms using seniority-based allocation rules, and show that such a scheme gives lawyers an incentive to further specialize. As in standard agency contracts, the mutual monitoring and risk sharing advantages to sharing contracts comes at the cost of incentives, and this tradeoff may help explain the coexistence of solo practice with group practice.

Given that there is a motive for professionals to form groups, the next question is why both single and multispeciality group practices exist contemporaneously. Again there is a tradeoff between the benefits and the costs of single speciality groups. According to Carr and Mathewson (1990) and Kandel and Lazear (1992), a clear benefit of single speciality groups is that professionals within a given speciality are best able to mutually monitor one another. Kandel and Lazear (1992) state that "partnerships tend to be formed among individuals who perform similar tasks because mutual monitoring is more effective" (p. 816). Yet the risk-sharing motive for sharing contracts developed by Cheung (1969) and Gilson and Mnookin (1985) provides an incentive for diversified groups when physicians are confronted with field-specific shocks such as technological innovation on the supply side, or changes in the incentive structure of health insurance contracts on the demand side. Thus the risk sharing motive promotes group diversity and so works against the mutual monitoring incentive for group homogeneity. This is a particular example of the possible "complementarities" motive for multispeciality groups discussed more generally by Farrell and Scotchmer (1988).

A second advantage of multispeciality groups arises from incentives for primary care physicians to refer patients internally. In particular, share contracts among primary care physicians on the one hand and surgeons and specialists on the other may give primary care physicians an incentive to screen patients so that only the most lucrative cases are internally referred. The same internal-referral motive exists when physicians have joint ventures with outside speciality practices. Self-referral involving outside facilities is considered a controversial practice because of these cream-skimming incentives. In fact Mitchell and Sunshine (1992) and Swedlow et al. (1992) offer considerable evidence that physicians use joint venture affiliations to "skim the cream" from the pool of patients by self-referring those patients with the best insurance, and then ordering costly procedures at a rate that exceeds the national average.[6] This evidence also supports the notion that multispeciality groups with an equal shares component to their sharing rule have a profitability advantage from cream-skimming self-referrals.

There is thus a tradeoff between the mutual monitoring advantage of single speciality groups, and the diversification and internal referral advantage of multispeciality groups. The presence of this tradeoff is consistent with the contemporaneous mixture of single speciality and multispeciality group practices.

Sharing rules determining physician income are of central importance to medical groups. For example, Beck (1972) and Azevedo (1990) argue that disputes over surplus division cause more medical groups to break up than all other factors combined. The comments of Ross, Williams, and Shafer (1984) are especially relevant here:

> "[T]he surgeon [has] an income advantage when worth is measured in terms of fees paid. The specialist in internal medicine may labor just as long, but... [the] skillful diagnostic talents [of the internist] are worth less — again, measured in terms of fees paid. Thus throughout the physician's professional life, compensation relationships may be affected. Disparity in income among specialties creates friction within groups....Probably the most common factor leading to

[6] the U.S. Department of Health and Human Services issued safe-harbor regulations limiting the use of self-referral to outside facilities in September 1991, while the Internal Revenue Service has taken the policy that not-for-profit hospitals may lose their tax-exempt status if they enter into self-referral joint ventures with physicians. In December 1991 the AMA approved ethical guidelines that advised physicians to avoid self-referral involving outside facilities where the physician has an ownership interest. Similar statements have been made by the American College of Physicians, the American College of Surgeons, and the American College of Radiology. While these referral incentives are also present in multispeciality practices, to my knowledge no restrictive policies have been proposed for them.

the complete dissolution of [medical] groups is the inability of the individuals in the group to agree on an acceptable method of compensation" (p 202, 209).

As Ross et al. point out above, heterogeneity in marginal revenue product is a fact of professional life in medicine. In particular, primary care physicians (family practitioners, internists, and pediatricians) who diagnose patients generally have much lower revenue products than the surgeons and specialists to whom they refer patients. This differential has existed for some time and is well-known by industry observers and policy makers. For example, McKay (1990) points out that the Health Professions Educational Assistance Act of 1976 instituted a quota scheme to encourage the offering of first-year residencies in primary care fields.[7] Using American Medical Association (AMA) data, McKay has computed mean annual physician net income (before taxes) and mean annual hours worked for eight medical specialties. Using her most recent data (1987), one can get a rough estimate of revenue product differences across these eight physician fields by dividing average annual net income by average annual hours worked:

Pediatrics	$85,300/2541	=	$33.57
Family Practice	$91,500/2561	=	$35.73
Internal Medicine	$121,800/2654	=	$45.89
Psychiatry	$102,700/2076	=	$49.47
Ob/Gyn	$163,200/2685	=	$60.78
Anesthesiology	$163,100/2446	=	$66.68
Surgery	$187,900/2491	=	$75.43
Radiology	$180,700/2323	=	$77.79

Thus the average net income per hour is more than twice as large as the smallest, and the three primary care fields are all below the other surgical and specialist fields, which is strong evidence for heterogeneity in revenue product across physician speciality fields.[8] Thus despite the inevitable heterogeneity across physicians within a given field, multispeciality medical groups are confronted

[7] While this quota scheme expired in 1980, McKay points out that the issues surrounding policies designed to encourage more residents to enter primary care fields resurface with regularity.

[8] The ratio of high to low average net income per hour has actually risen over time from 1.49:1 in 1970 to 1.78:1 in 1980 to 2.32:1 in 1987.

with an additional heterogeneity based on revenue product differentials across fields.

While rules specifying equal sharing may be desirable because of their superior risk-sharing properties, an "equal shares" hypothesis predicts that as productivity differences increase in groups bound together by a sharing contract, the use of productivity-indexed sharing rules will increase, while the use of rules specifying equal sharing will decrease. Two testable implications follow from this hypothesis. First, rules specifying equal sharing are predicted to be used with substantially lower frequency in multispeciality groups relative to single speciality groups because of revenue-product heterogeneity across fields.[9] Second, group size in share contracts specifying equal sharing is predicted to be smaller than in contracts that weight productivity.

This latter prediction follows from theoretical work by Farrell and Scotchmer (1988), who show that when there are scale economies to group production, and individuals have heterogeneous abilities, then share contracts specifying equal sharing are "inefficient because people cannot exploit economies of scale except by sharing with less able people" (p. 281). The inefficiency arises because equal sharing groups are too small to fully exploit the available scale economies, since the bigger the group the bigger the range of ability types, and so groups are small because individuals with the highest abilities are unwilling to subsidize those with much lower abilities. Groups can overcome this limit on size if they can index their sharing rules to productivity. As a result the prediction is that groups

[9] There are a number of factors that could undercut this hypothesis. The first would arise if little or no equal sharing were observed in single speciality groups. In fact equal sharing occurs in a little over one-third of all single speciality groups in the survey. The second would arise if multispeciality groups were sufficiently more profitable than single speciality groups that the surplus premium makes equal sharing in multispeciality groups acceptable to physicians in high revenue product fields. There is little evidence to support this notion. Both single speciality and multispeciality groups coexist in large numbers in the medical industry, and as Fama and Jensen (1983) argue, "...there is competition among organizational forms for survival in any activity" (p. 327). Moreover, there is an underlying tradeoff between mutual monitoring and risk-sharing that belies the presumption of a general profitability advantage to multispeciality groups. Thus there is little evidence that multispeciality groups are substantially more profitable than single speciality groups, and so the revenue product differentials create meaningful feasibility constraints on equal sharing rules.

using productivity-indexed sharing rules will tend to be larger than groups that share equally. Note that if the population of individuals is sufficiently large, with replication of individual ability types, then heterogeneity will not limit equal sharing groups, since equilibrium groups will form around largely homogeneous skill attributes. Moreover, the increased revenue-product heterogeneity in multispeciality groups should magnify the effects of rule form on group size.

Description and Analysis of the Data

The data are from a 1986 survey of medical group practices conducted by George Auld of the American College of Medical Group Administrators. Auld mailed out survey instruments to 3000 medical group practices throughout the United States, making up approximately one-half of the membership of the Medical Group Management Association (MGMA).[10] 1264 completed responses were received. Respondent physician groups are primarily organized as partnerships or professional corporations. They do not include hospitals or health maintenance organizations or university departments, although physician groups may have contractual or other relationships with these organizations. The data include observations on type of group practice, number of physicians, and surplus sharing rule. The survey includes 758 observations on various types of single speciality groups, and 506 observations on multispeciality groups.

It is interesting to point out that the vast majority of medical group practices compensate physicians using a linear sharing formula that weights an equal shares component and a component tied to "productivity" (which generally reflects revenue product measured by gross charges or net collections, and may be factored net of direct costs, or with credit given for lab or radiology tests). In fact, on average only 3 percent of joint surplus was divided based on a weighted factor other than

[10] Membership in the MGMA is open to all groups with at least three physicians.

equal shares or a productivity measure.[11] This use of simple linear sharing rules conflicts with the more intricate incentive contracts derived from traditional principal-agent models, which predict large differences in compensation from very small differences in outcomes. In such circumstances the optimal rule is quite sensitive to the distributional assumptions of the model, and so has limited empirical relevance. In contrast, Holmstrom and Milgrom (1987) argue that linear sharing rules are "strikingly robust," and are consistent with optimal compensation schemes in much richer environments in the field. The widespread use of linear rules in medical group practices appears to offer support for the Holmstrom and Milgrom model, and is consistent with the use of linear sharing rules used in diverse share contract settings as Japanese firms (Kandel and Lazear, 1992), common-pool resource groups (Hackett, Schlager, and Walker, 1992), worker-managed firms (Benham and Keefer, 1991), share-cropping (Cheung, 1969), franchising (Hackett, 1989), brokerage (Hackett, 1992), and law firms (Gilson and Mnookin, 1985).

As mentioned above, one testable implication of the equal shares hypothesis is that rules specifying equal sharing will be used with less frequency in multispeciality groups than in single speciality groups. This hypothesis is strongly supported by the available evidence. To see this, first consider Figure 1, in which I plot the weight assigned to equal shares in allocation rules used in multispeciality and single speciality medical groups. Note that rules specifying equal sharing are used in only 4 percent of all multispeciality groups, while they are used in 35 percent of all single speciality groups. More formally, the question is whether this difference in the distribution of sharing rule forms is significant. This hypothesis is tested using standard nonparametric techniques. Two techniques commonly used in this context are the Wilcoxon and the Kolmogorov-Smirnov tests. In the Wilcoxon test procedure both samples are combined into a single ordered sample, and then ranks

[11] The "other" category may reflect activities such as administration or research, or simply a seniority premium.

are assigned to the sample values from the smallest to the largest. The ranks are then summed for each of the two samples, and the difference is then taken between these sums. The null hypothesis is rejected if in absolute value the difference is sufficiently large. The Kolmogorov-Smirnov test computes the sample cumulative distribution functions, and computes the maximum of the absolute value of the difference between the distribution functions. If this difference is sufficiently large in absolute value, the null hypothesis can be rejected.

The nonparametric test results strongly reject the null hypothesis of no difference in underlying distribution of sharing rule across single speciality and multispeciality groups. The Wilcoxon Z value is -11.53, and the associated significance level is .00001. Similarly the Kolmogorov-Smirnov procedure generated a maximum absolute difference D = .378, with an associated significance level of .00001. These results are not sensitive to the test procedure, and affirm what our eye can tell us; namely, that the available evidence strongly supports the hypothesis.

Summary information on sharing rules used in particular medical group practices is given in Table 1. The analysis summarized in Table 1 shows that while there is substantial variation in the frequency of rules specifying equal sharing across particular single speciality groups, in every case this frequency is larger than that for all multispeciality groups.[12] A Wilcoxon two-sample test rejects the null hypothesis of no difference in distribution of sharing rule (comparing the multispeciality sample to each of the particular single speciality samples) in 13 of 16 cases. In two of the remaining three cases (psychiatry and otolaryngology), the inability to reject is driven in large measure by the attenuation of test power by small sample size. This more disaggregated analysis shows that while groups in a few speciality fields may use sharing rules similar to multispeciality groups, the aggregate findings are supported by disaggregated analysis in over three-fourths of the

[12] While this variation in rule form across single speciality fields is a facinating empirical anomaly, this question goes beyond the scope of the present paper.

single speciality fields.

A second testable implication of the equal shares hypothesis is that the number of physicians in equal sharing groups is predicted to be less than or equal to the number of physicians in groups that use productivity-weighted sharing rules. This prediction is tested by comparing the number of physicians in two samples, one made up of groups using equal shares rules, and the other made up of groups using some form of productivity-weighted sharing rule. The results of this analysis are summarized in Table 2. The mean number of physicians in equal sharing groups is 7.9, while the mean number of physicians in groups using productivity-indexed rules is 16.7. This difference in means is significant using a T-test (significance = .0001), and the underlying distribution of number of physicians is found to be significantly different across the two samples using a Wilcoxon test (significance = .00001).

A disaggregated analysis of the group size hypothesis is given in Table 2, and reveals an interesting variation in the sensitivity of group size to sharing rule form that is otherwise hidden in aggregated analysis. First, the aggregate result is magnified in samples limited to multispeciality groups, where the mean number of physicians in groups using productivity-weighted sharing rules is nearly twice as large as that in groups using a strict equal sharing rule. This result is consistent with the notion that the factors limiting the number of physicians in equal sharing groups are intensified by revenue-product differences across speciality types. Second, the group size effect is either not present at all or is actually reversed in two-sample analysis limited to single speciality groups. Average number of physicians in equal sharing single speciality groups is 7.37, while the mean number in groups indexing their sharing rule to productivity is 6.61, and both the Wilcoxon and the T tests are significant at the 3 percent level. Note that Radiology and Pathology groups both tend to share equally and to be large, and if these groups are removed from the aggregated single speciality sample, both the reversal and the significance disappear.

The analysis suggests that the increased revenue-product heterogeneity in multispeciality groups significantly limits the size of equal sharing groups. Moreover, the analysis finds little support for the group size prediction in single speciality groups. Recall, however, that the group size prediction vanishes for very large populations with replication of individual skill types, because single speciality groups can form around a particular skill level. If the population of physicians is sufficiently large to allow single speciality groups to form around a particular skill type, then group size should only matter for multispeciality groups where revenue-product differences across specialities limits the diversity, and likely the size, of multispeciality groups using an equal sharing rule. Given the large number of physicians in the U.S., this interpretation is both plausible and consistent with the results. In particular, there was not significant difference in group size associated with sharing rule form in individual speciality categories, with the exception of the multispeciality category.

A puzzle that remains from this analysis is the important role of pure productivity-indexed sharing agreements in multispeciality groups. Pure productivity-indexed sharing rules prevent groups from exploiting many of the benefits of group production identified in the theoretical literature. In particular, both the risk sharing and the internal referral motives for multispeciality groups are predicated sharing rules having a weighted equal shares component. The absence of an equal shares component in nearly 45 percent of multispeciality groups suggests that in many cases these motives are not too strong. Yet if this is the case, then the mutual-monitoring advantage of single-speciality groups must also not be very strong, or else multispeciality groups would not form. If none of these three motives for group formation are operational, then we are left with a pure scale economies motive for group formation, likely with asset specificity explaining the long-term nature of these arrangements. It should be noted, however, that rules including an equal shares component are used in over 50 percent of the sampled multispeciality groups, and about a third of the sampled single speciality groups. These multipart rules are consistent with the broader set of motives for group formation discussed above. Convex combination sharing rules also appear to be associated with laboratory sharing contracts, as will be discussed in detail below.

III. A LABORATORY INVESTIGATION OF EX POST SHARING RULE AGREEMENTS IN INCOMPLETE CONTRACTS

The Model

The second part of this study focuses on one-shot incomplete contracts, with sharing rules negotiated after the parties have sunk their investment in enhancing the expected joint return. A simplified version of the two-stage incomplete contracting model described in Hart and Holmstrom (1987), Tirole (1988), and Holmstrom and Tirole (1989) was created for laboratory experimentation. The situation underlying the model is one in which a buyer and seller have agreed to trade one unit of some good in the future.[13] They agree to a basic design for the good, but cannot contract up-front over all aspects of a quality-enhancing product improvement to be realized in the future. In order to simplify the decision setting, the value and cost associated with the basic design are normalized to zero, and so the decision setting described below is based on the added valuation and cost of the product improvement.

The incomplete contracting process is outlined in Figure 2 and described in detail below. In the first stage the buyer's induced value (V) of the product improvement is uncertain, and can either be "high" (V_h) or "low" (V_l). Similarly the seller's induced cost (C) of the product improvement can either by "low" (C_l) or "high" (C_h). The process begins with the buyer and seller non-cooperatively making sunk investments that increase expected value and decrease expected cost. In the first stage the buyer chooses the likelihood that value is high by choosing a number $0 \leq X \leq 1$ at (sunk) cost

[13] The example that follows frames incomplete contracts in a vertical relationship, as is also done in the experiments. As in Grossman and Hart (1986), however, incomplete contracts can equivalently be framed in the context of lateral or horizontal relationships.

X^2. Likewise the seller chooses the likelihood that cost is low by choosing a number $0 \leq Y \leq 1$ at (sunk) cost Y^2.

After the buyer and seller choose X and Y in the first stage, the second stage begins with the realization of value and cost. Value is determined by comparing X to a random number drawn from a uniform distribution over the unit interval; if X is greater than or equal to the random number, then value is high, and otherwise value is low. Cost is likewise determined by comparing Y to a random number drawn from a uniform distribution over the unit interval; if Y is greater than or equal to the random number, then cost is low, and otherwise cost is high. V, and C then become common knowledge. Buyers and sellers then decide whether or not to bargain over shares of realized surplus (V-C).[14] After any bargaining, either the buyer or the seller can veto the product improvement, which has the effect of causing V and C to become zero.

If one or both parties reject bargaining, or if attempted bargaining breaks down, the buyer is paid V, and the seller incurs a cost of C. Such an outcome is not an equilibrium, however, because if bargaining fails, the seller is always better off to veto the product improvement. The buyer is motivated to bargain because of the seller's ability to credibly commit to a veto if surplus is not shared. Were it not for the seller's ability to veto, the buyer would not have an incentive to bargain and share the surplus realization (this is the role of vertical integration in the Grossman and Hart (1986) model). There are two implications: (i) bargaining and no veto are the equilibrium of the

[14] For example, even if they did agree to a profit sharing rule, they cannot preclude future renegotiation once joint surplus is realized. This is especially true in agreements involving human capitalists (such as professional partnerships) in which constraints on involuntary servitude allow individuals to threaten breakup if surplus shares are not renegotiated. The step allowing subjects to skip bargaining can be omitted with no violence to the properties of the model, as it is equivalent to a breakdown of bargaining in terms of the seller's dominant strategy to veto. This step was added for laboratory investigation so subjects not wanting to bargain would not hold up the others. If such a subject was instead forced to bargain, the desire not to bargain could be expressed by rejecting all share proposals, and making unacceptable proposals (e.g., 100, 0), until breakdown of the bargaining process is realized.

second stage sub-game, and (ii) ignoring sunk investments, parties have no induced outside option payoffs in equilibrium. If bargaining is successful, the outcome is a buyer share s and a seller share (1-s) of realized surplus, where $0 \leq s \leq 1$.

Parties foreseeing the outcome of second stage bargaining can then compute their expected payoff-maximizing first stage investment. The research question posed here focuses on the relationship between bargaining outcomes and sunk, transaction-specific investments. In order to test this hypothesis one must first be specific about the bargaining institution. The laboratory bargaining setting is based on a variant of the alternating offer protocol developed by Rubinstein (1982) and Stahl (1972). In the Rubinstein procedure the parties alternate in making proposals indefinitely until a proposal is accepted or the negotiations break down. Some mechanism is required to give parties an incentive to reach early agreement. The particular mechanism investigated here is a probability of forced breakdown upon the rejection of a proposal, described in Binmore et al. (1991), hereafter referred to as BMSS. Upon rejection of a proposal, a random move determines whether another round of negotiations will be allowed, or bargaining will end with breakdown.

Perfect Equilibrium Hypothesis: The "forced breakdown" sequential bargaining protocol was chosen because in this application it has a unique subgame-perfect bargaining equilibrium of equal shares that also corresponds to the Nash bargaining solution. This equilibrium has the important property that the allocation of realized surplus is independent of the relative levels of sunk, transaction-specific investment committed to by the buyer and the seller, as assumed in the contracting literature.[15]

The subgame-perfect equilibrium share s* in turn affects investment incentives in the first stage of the incomplete contracting process. It is useful at this point to establish a theoretical benchmark. If V and C are independent random variables, and if the buyer and the seller are risk-neutral and

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[15] **See Hackett (1993) for a demonstration of this independence.**

capable of perfect foresight, then the buyer will choose X^* to maximize:

$$(1) \qquad s^*[X(Y(V_h-C_l)+(1-Y)(V_h-C_h)) + (1-X)(Y(V_l-C_l)+(1-Y)(V_l-C_h))] - X^2.$$

The first term is simply the buyer's share of the expected value of (V-C). The seller will similarly choose Y^* to maximize

$$(2) \qquad (1-s^*)[Y(X(V_h-C_l)+(1-X)(V_l-C_l)) + (1-Y)(X(V_h-C_h)+(1-X)(V_l-C_h))] - Y^2,$$

where the first term is the seller's share of the expected value of (V-C). Maximizing equations (1) and (2) with respect to X and Y yields:

$$(3) \qquad X^* = s^*(V_h - V_l)/2,$$

$$(4) \qquad Y^* = (1-s^*)(C_h - C_l)/2.$$

This benchmark analysis illustrates the one-way influence that is a property of the incomplete contracting model. Bargaining solutions have a direct influence on buyer and seller investment incentives, as shown in (3) and (4). It is important to point out, however, that the perfect equilibrium hypothesis predicts bargaining outcomes independent of any preceding sunk investments.

Equity-Theoretic Hypothesis: In a recent survey Ochs and Roth (1989) find that experimental tests of the perfect equilibrium bargaining hypothesis have generally been able to strong reject the hypothesis. The accumulated evidence suggests that non-strategic factors may have a substantial effect on bargaining outcomes. Accordingly, I consider an alternative hypothesis in the tradition of equity theory. Guth (1992) has developed a behavioral theory of distributive justice that predicts surplus sharing rules that vary as a function of the information content of the bargaining environment. The essential structure of his model is outlined below. I then apply Guth's model to the incomplete contracting setting in order to create a specific testable hypothesis.

His model begins with the hypothesis from equity theory that payoff rewards be allocated in proportion to an individual's contribution to that reward; that is, $R_i/C_i = R_j/C_j$, where R and C refer to rewards and contributions, and subscripts refers to negotiators. To evaluate this hypothesis Guth offers a set of conditions which together are sufficient for a particular variable to act as a standard to measure contributions or rewards. These are:

1. Local Monotonicity (LM): All participating individuals must be interested in smaller individual contributions and higher individual rewards.

2. Interpersonal Observability and Measurability (IOM): Individual contributions and rewards must be observable and measurable by all n parties.

3. Relevance of Contributions and Rewards (R): Among all individual variables satisfying condition IOM the individual contribution must be the most relevant investment for the group's success and the individual reward must be the most closely related variable to the individual satisfaction resulting from participating in the group's success.

4. Approximate Homogeneity of Individual Contributions and Rewards (H): Suppose there are two individuals, i and j. Then the equity norm is only applied when contributions C_i and C_j, as well as rewards R_i and R_j, are very similar, i.e. nearly exchangeable in view of the group's input-output relationship.

5. Nearly Linear Relationship between Input and Output (L): The marginal productivity of a further contribution by individual i should be close to R_i/C_i. I.e., the reward level depends linearly on the contribution level.

A variable that meets these conditions qualifies as a standard. These standards are then ranked based on their information requirements. The standard with the most restrictive information requirement is referred to as the superior standard. Guth then hypothesizes that the superior standard will be used when its information requirements are met at reasonable cost. Importantly, the equity-theoretic hypothesis is not consistent with parties having fairness arguments to their utility functions; Guth holds that utility functions are used to describe social decision problems, and therefore should not include results (such as fairness concerns) from analysis of social decision problems.

In this incomplete contracting study the reward to be divided is the surplus measure (V-C). There are two standards that can be used to measure a party's contribution to this reward. The first is a party's cash investment in value enhancement X^2 or cost reduction Y^2. The second is a per-capita standard based, on each party's equal status in the experiment. Since investment cost is dollardenominated, conditions (LM), (R), and (H) are met as long as the experiment successfully induces value. From equations (3) and (4) we know that condition (L) is met. Importantly, condition (IOC) is only met when investments are observable. Guth argues that the personal standard will always be used if there is no superior standard for measuring contributions, which is the case here when information on each party's investment is withheld.

Guth's model predicts that bargaining will divide rewards proportionately with contributions. Thus the testable equity-theoretic hypothesis is that when bargainers know each others' costly investment in surplus enhancement, then bargaining will divide surplus proportionately with investment costs. As a result $s^e(V-C)/X^2 = (1-s^e)(V-C)/Y^2$, where s^e is the bargaining outcome from equity theory, determined by the equation:

(5) $$s^e = X^2/(X^2 + Y^2).$$

That is, the buyer's equitable share of (V-C) is equal to his share of overall investment, when such information on contributions is provided. When investment information is not provided, investment costs no longer are a contribution standard because they do not meet condition IOC. The per-capita or personal standard remains, and the equity-theoretic hypothesis predicts that bargaining will divide surplus proportionately with the per-capita standard, resulting in an equal split. Thus under the personal standard:

(6) $$s^e = 0.50.$$

Laboratory Parameterizations and Predictions

Three parameterizations are used. In the first, induced buyer and seller investment incentives are equal; V can take on the values of $5 or $3, while C can take on the values of $2.50 or 50 cents. Thus both buyers and sellers can increase surplus by up to $2 with their investment. One advantage of this parameterization is that bargainers cannot infer heterogeneity in investment cost shares (the superior contribution standard) from the identical induced investment incentives. Yet because of differences in subject-specific characteristics such as risk attitudes, equity norms, and beliefs regarding the characteristics of their bargaining partner, variation in investment can be expected to occur even under this parameterization.

Two additional parameterizations are devised with the idea of inducing widely different investments on the part of the buyer and the seller, and so allowing for the evaluation of the predictive power of the hypotheses under extreme circumstances. In one of these, relatively strong buyer incentives are induced by having the potential gains to buyer investment be large relative to those of the seller. In this parameterization V can take on the values of \$5.50 or \$2.50, a potential gain of \$3, while C can take on the values of \$2.10 or \$2, implying a potential gain of only 10 cents. From equations (3) and (4) perfect equilibrium bargaining implies $X^* = .75$ and $Y^* = .025$. If investments are observable, then from the superior contribution standard the buyer's surplus share s^e will be proportionate with his investment cost share $X^2/(X^2 + Y^2)$, implying $X^e = 0$, $Y^e = 1$, and $s^e = 0$. If investments are unobservable, then $X^e = X^*$, $Y^e = Y^*$, and $s^e = s^* = .5$. The other parameterization is symmetric with the first, inducing strong seller incentives.[16] Under the subgame-perfect bargaining equilibrium hypothesis $s^* = .5$; From equations (3) and (4) we have $X^* = .025$ and $Y^* = .75$. If investments are observable, then from the superior contribution standard the buyer's surplus share s^e will be proportionate with his investment cost share $X^2/(X^2 + Y^2)$. Solving X^e, Y^e, and s^e simultaneously as before, we have $X^e = 1$, $Y^e = 0$, and $s^e = 1$. If investments are unobservable, then $X^e = X^*$, $Y^e = Y^*$, and $s^e = s^* = .5$.

Participant's Decision Environment

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[16] In this case sellers can decrease cost by up to \$3, while buyers can increase value by only \$0.10; V can take on the values of \$5 or \$4.90, while C can take on the values of \$4.50 or \$1.50.

Subjects were recruited from economics and business economics courses at Indiana University, and had no prior experience with the experiment. Eight subjects were used in each experiment, except in two cases in which poor turnout required the use of six subjects. The experimental setting is computerized, and consists of ten rounds of the two stage incomplete contracting game played under one of the four treatment conditions.[17] Because subjects experienced only one treatment condition, the problem of assessing the effects of experience in one treatment on behavior in a later treatment is avoided.

A number of measures were taken to attenuate any repeat-relational contracting motives in ex post sharing rule negotiations. First, recruitment practices prevented the selection of session groups from homogeneous settings such as the same class, dorm, or sorority. Second, subjects were assigned computer terminals at locations isolated from one another. Third, participants were randomly and anonymously matched each round. Fourth, the message space allowed in ex post bargaining was completely controlled through a computerized bargaining setting.

The experimental design is given in Table 3. Multiple repetitions of a particular treatment were carried for each of the four conditions. These include four repetitions in which investment incentives induced on buyers and sellers are equal, and investments are observable (OI-EII). Data are also reported from four repetitions in which investment incentives induced on buyers and sellers are equal, and investments are unobservable (UI-EII). In order to evaluate the hypotheses under more extreme circumstances, three repetitions from each of two additional parameterizations are considered under the OI information treatment — strong induced seller incentives (OI-SSI), under which sellers are anticipated to make the great majority of total investment, and strong induced buyer incentives (01-SBI), under which buyers likewise are anticipated to make the great majority of total investment.

[17] The programming which enforces the information and message constraints of the experiment, and which performs record-keeping, is written in FORTRAN and operates on a VAX mainframe computer at Indiana University.

This experiment builds on my earlier work in Hackett (1993) by adding the UI-EII treatment, which enables more complete testing of the equity-theoretic hypothesis.

The order of events in a given decision round were as described in Figure 2 above. Subjects were first seated at their computer terminals and read the experimental instructions. Subjects then worked through a questionnaire designed to assess their understanding of the experiment (instructions and questionnaire for the OI-EII treatment is provided in the appendix). Subjects' computer accounts were then credited with a $4 initial balance and begin the experiment. To help subjects become familiar with the experimental procedures without experiencing loss exposure, and following BMSS, decisions are made without cash reward in early (the first two) rounds.

Once subjects are matched and assigned a buyer or seller status, they anonymously and noncooperatively choose a level of sunk investment X and Y as described above. At the beginning of the second stage V and C are determined after the random number n is realized and compared to X and Y. To prevent parties from deducing each other's investment from n and the outcome of V or C, independent draws are performed for buyers and sellers in the UI condition.[18] The n drawn for buyers in each of the ten rounds are:

.04, .65, .38, .38, .02, .60, .72, .12, .87, .21

while the n drawn for sellers in each of the ten rounds are:

.21, .62, .14, .11, .85, .71, .04, .56, .83, .50

These draws are fixed in advance, and given the samples one cannot statistically reject the hypothesis that n was randomly drawn from the unit interval for either set. V and C are then revealed to both

[18] Only one random number sequence was used in the OI experiments, as the inference problem was eliminated by directly revealing investments.

the buyer and the seller.[19] Under information condition 0I, X and Y are also revealed to both the buyer and the seller. Each subject then chose whether to enter the process of bargaining over (V-C). If both parties agree to bargain, they then proceed into the laboratory alternating offer bargaining procedure used by BMSS. In odd numbered contracting rounds buyers make the first offer, while in even numbered rounds sellers offer first. Rejection of a share offer leads to a chance that negotiations will exogenously be ended and no sharing will occur in that round. Following BMSS I use the technique of fixing in advance the number of allowed rejections before forced breakdown.[20] The maximum number of rejections allowed in each of the ten rounds are:

9, 2, 11, 2, 10, 7, 16, 12, 8

BMSS state that the two short games were intended to convince subjects that a forced end to bargaining could occur, and that otherwise one could not statistically reject the hypothesis that upon rejection a breakdown occurs independently with probability 0.1. Given the discount rate of .9, the subgame-perfect equilibrium has a first offer of .474 accepted, which approximates .50 as the discount rate converges to 1.00.

Finally, subjects privately and noncooperatively decide whether to veto. Subjects are told that a veto implies the hypothetical product improvement will not occur, and consequently V and C fall to zero. After the veto decision each subject has their payoff for the round added to their cash account.

Analysis of Laboratory Results

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[19] Subjects are told that this information will be made known to both parties. By randomizing whether subjects were buyers or sellers in a given period, it will become clear to the subjects that the announced common knowledge of these parameter values is in fact true.

[20] Specifically, subjects are told (without subterfuge) that "[t]he total number of share offers that can be made by you and the other party is limited, and has been fixed in advance....You should reckon that there is a 90 percent chance that at least one more share offer can be made." BMSS report initial difficulty in communicating breakdown probabilities to subjects, which lead them to fixing them in advance.

Results are reported from a total of fourteen experimental sessions, nine of which have been previously reported in Hackett (1993).[21] To attenuate any added complication of learning effects, and following BMSS, the analysis reported below is restricted to data from later rounds of each repetition. In particular, the analysis below is based on 270 observations generated in the last five rounds of each of the fourteen experimental sessions.

Recall that the contracting game is structured so that if buyers refuse to bargain, or if an excess of proposal rejections causes bargaining to break down, the testable hypothesis is that sellers will veto. In fact buyers refused to bargain a total of 14 times, and each tine the relevant seller subsequently vetoed. Forced breakdown of bargaining (from an excess of refused proposals) occurred a total of 12 times, and in 11 of these the seller subsequently vetoed. In one instance a seller refused to negotiate, and subsequently vetoed. These results generally support the prediction of the veto hypothesis. A total of 243 successful surplus sharing agreements remain, and are evaluated below.

The Data

The Ochs and Roth (1989) survey identify a number of empirical regularities in laboratory ultimatum and sequential bargaining experiments. First, the use of a non-trivial breakdown probability results in the prediction of a small first mover advantage in bargaining, and many experiments support this hypothesis. A 10 percent breakdown probability generates a prediction of an opening proposal being accepted that gives the proposer 52.6 percent of surplus. This first mover advantage is tested for by constructing two samples — one in which the buyer was the first mover, and one in which the seller was the first mover - and then performing a t-test for the hypothesis that the mean buyer surplus share is equal in the two samples. The null hypothesis of equal means cannot

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[21] The new sessions are the four UI-EII session repetitions and the last OI-EII session repetition.

be rejected at standard significance levels.

Second, while the equilibrium prediction is for first proposals to be accepted, Ochs and Roth find that between 10 and 29 percent of first offers were rejected in the studies they survey. In the present study the overall first offer rejection rate was 75 percent (193/256), with the mean rate by treatment ranging from 63 percent in OI-EII to 80.6 percent in UI-EI1.[22] Third, because costly investment was generally rewarded with larger surplus shares, sharing rule agreements tended to deviate from equilibrium predictions in the direction of equal (surplus) division, which is also consistent with the regularity in the Ochs and Roth survey.[23] A final regularity observed in past studies is a high rate of disadvantageous counterproposals in which the decider counterproposes a sharing rule that yields him a payoff smaller than that in the proposal he rejected. In this study only 6 of the 193 counterproposals were disadvantageous, which is substantially less than the rate observed in past studies. Thus the pattern of "unpredicted" regularities changes somewhat when bargaining occurs in the context of an incomplete contract.

The bargaining outcomes for the experiment, expressed in terms of a buyer's surplus share s, are given in the four panels of Figure 3. Bargaining outcomes in panels a. and b. are from four experimental sessions each of OI-EII and UI-EII, respectively. Bargaining outcomes in panels c. and d. are likewise from three experimental sessions each of OI-SSI and OI-SBI, respectively.

Compare bargaining outcomes in panels a. and b. In both cases the data are clustered around the

[22] The first offer rejection rate is much higher here than in other alternating offer bargaining experiments, of which the 15 percent observed by BMSS is representative. The added complexity of bargaining preceded by sunk investments may account for this increase, although it is interesting to note that the highest rate of first proposal rejection occurs when these investments are unobservable. The high rate of first proposal rejection probably accounts for the lack of evidence for the first mover advantage. I interpret this result later in the section.

[23] A bargaining hypothesis that predicts outcomes based on net payoff equalization would be confounded by the finding here (and elsewhere) that net payoff differences are reduced but not eliminated. See Hackett (1993) for a more detailed discussion.

buyer share of .5 predicted by the perfect equilibrium hypothesis.[24] A two-sample non-parametric test of the hypothesis that these two samples are generated by the same underlying stochastic process is strongly rejected at well below the one percent significance level using both the Wilcoxon and the Kolmogorov-Smirnov procedures. The failure of this hypothesis is largely driven by the greater variation in bargaining outcomes under OI-EE: only 25 percent were equal shares, while 63 percent were equal shares under UI-EII. Buyer surplus shares are biased from below in panel c, where on average buyers contributed only 2 percent of total surplus-enhancing investment. In contrast, buyer surplus shares are biased from above in panel d., where on average buyers contributed 98 percent of total surplus-enhancing investment.

The apparent relationship between surplus shares and cost shares is investigated more formally below.

Estimation and Hypothesis Testing

The relationship between surplus shares from bargaining (expressed in terms of the buyer's surplus share (BSURPSHR)) and shares of joint-surplus-enhancing investment is estimated below using ordinary least squares multiple regression analysis. Recall that buyer investment increases the probability X (at cost X^2) of a high value realization, and likewise sellers' investment increases the probability Y (at cost Y^2) of a low cost realization. Accordingly the key independent variable (BCOSTSHR) is the buyer's investment cost share $X^2/(X^2+Y^2)$. The intercept establishes the point estimate for a buyer's surplus share when the buyer makes a zero contribution to surplus-enhancing investment. Dummy variables are used to estimate the (fixed) effects of variation in information (observable or unobservable investments) and parameters (induced investment incentives) on the

[24] As I shall show below, buyer surplus shares are somewhat biased from above in panel b. because buyers tended to have made a greater share of total investment, and accordingly a positive coefficient is estimated. Why buyers tended to make greater investment when induced incentives were identical remains an open question. It is possible that seller investment to avert cost is cognitively different from buyer investment to enhance value.

relationship between surplus shares and investment cost shares. Thus data are pooled across experimental sessions by information treatment and parameterization.[25] Variable names starting with UI, SSI, and SBI refer to the UI-EII, OI-SSI, and OI-SBI treatments, respectively. These variables are zero except in their respective treatment or parameter condition, in which case variables ending with "INTDUM" take on the value of 1, while variables ending with "SLDUM" take on the value of BCOSTSHR. The model is estimated as follows:

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BSURPSHR =    .357*INTERCEPT (10.67; .0001)
                 + .18*UHNTDUM (4.51; .0001)
                 + .06*SSnNTDUM(1.71; .09)
                 + .25*SBDNTDUM (1.36; .18)
              + .33*BCOSTSHR (5.58; .0001)
                 - .38*UISLDUM (-5.54; .0001)
                 - .ll*SSISLDUM(-0.69; .49)
                 - .34*SBISLDUM (-1.74; .083),
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where the first number in parentheses is the relevant T-statistic for the two-tailed test of the null hypothesis that the parameter is zero, and the second number is the probability of rejecting the null when it is actually true (type 1 error). The adjusted R^2 for the regression estimation is .472, and the F-statistic is significant at well below the one percent level.

One could argue that since the dependent variable is restricted to the unit interval, the observed dependent variable is censored with regard to the true (unobservable) response. This is tested for by

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[25] Pooling data in this way may mask session-specific variation. To evaluate potential session-specific variation, separate regressions were run for each of the four information and parameterization conditions, and each included fixed effects dummies for each component session. There was no significant intra-session effect in three of the four conditions. Significant intra-condition variation was only observed in the OI-SSI treatment, with the standout being the first session. The intercept term for this parameterization was estimated to be .38 overall, but .46 in the first session. Moreover, while a positive and significant coefficient was estimated for the BCOSTSHR variable overall, a negative but significant coefficient was estimated for the first session. It is important to point out that buyer investment cost shares ranged from a high of 36 percent, in which the buyer received 38 percent of surplus, to eight observations on the low of 0 percent, in which on average the buyer received 49 percent of surplus. While in all but one case buyer surplus shares were no greater than .5 in this session (the standout was 51 percent), a negative coefficient on cost shares was estimated. These regressions with session dummies generally support pooling across session.

running a two limit Tobit specification on the above model. The coefficient estimates under Tobit are identical to those under OLS (with precision four characters to the right of the decimal point), with no substantial changes in significance. Second, the null hypothesis of homoskedasticity can be retained using a White test at usual significance levels. Third, from Figure 4 one might imagine that a cubic polynomial specification with inflection point somewhere near (50,50) would better fit the data than the linear specification used above. In fact the hypothesis of a cubic polynomial relationship between BSURPSHR and BCOSTSHR can be rejected. The OLS specification seems to work well.

Now consider the economic implications of the OLS estimation given above. A minimum buyer surplus share of 36 percent and a weight of .33 on a buyer's share of total investment cost are estimated under the OI-EII treatment. Both of these point estimates are highly significant. Given that the mean value of BCOSTSHR in this treatment is .55, then on average the buyer's surplus share is .36 + .33*.55 = 54 percent, to which the constant term contributes a 2/3 weight, while the buyer's investment cost share contributes the remaining 1/3. In contrast, the dummy variables UHNTDUM and UISLDUM are highly significant, indicating that going from observable to unobservable investments (holding induced investment incentives and all other controllable effects constant) has a significant effect on the point estimates. In particular, under the UI-EII treatment the estimated coefficient on the constant term is .54 - the sum of the coefficients estimated on the constant term of the regression and on the intercept dummy UHNTDUM. Likewise the estimated coefficient on a buyer's share of total investment cost is .33 - .38 = .05, which is not different from zero at standard significance levels. Thus when investment are unobservable, on average the constant term contributes a 100 percent weight in the surplus sharing rule (mean buyer surplus share is 54 percent).

Both hypotheses can be rejected using more formal hypothesis testing techniques. The perfect equilibrium hypothesis predicts that the coefficient on INTERCEPT will be 0.5, while all other coefficients will be zero. Expressing this hypothesis as a joint null, the resulting F-statistic is 29.77, which rejects the null at well below the one percent level. Similarly the equity-theoretic hypothesis predicts that the coefficient on INTERCEPT will be zero, the coefficient on BCOSTSHR will be 1.0, the coefficient on UHNTDUM will be 0.5, the coefficient on UISLDUM will be 4.0, and all other coefficients will be zero. Expressing this hypothesis as a joint null, as done for the perfect equilibrium hypothesis, the resulting F-statistic is 474.9, which rejects the null at well below the one percent level. Thus, as formulated, neither of the hypotheses successfully predict bargaining outcomes when bargaining occurs in the context of an incomplete contract.

Finally, note that the dummies for the OI-SSI and OI-SBI treatments are only marginally significant, suggesting that the estimated components of surplus sharing rules under more severe investment heterogeneity are not much different from those under OI-EII. This can also be seen in Figure 4, in which buyer shares of (V-C) are plotted against buyer shares of total investment cost $X^2/(X^2+Y^2)$ in Figure 4, using data from all ten experimental sessions that featured observable investments. The equity-theoretic hypothesis predicts outcomes along the 45-degree line, while the perfect equilibrium hypothesis predicts outcomes along the horizontal line. The estimated regression line is also plotted. The plot illustrates the basic regression result that when investments are observable, the perfect equilibrium hypothesis cannot be supported, and only limited support is found for the equity-theoretic hypothesis. Regression estimation of surplus sharing rules reflect a convex combination of equal shares and shares indexed to investments. Possible explanations for this unanticipated result are given below.

Heterogeneity and Multipart Surplus Sharing Rules: Some Possible Explanations

The estimation of surplus sharing rules comprised of a convex combination of equal shares and shares indexed to investments leaves us with a puzzle. First, one might argue that 100 percent proportionate rules will not arise because doing so would imply a nearly zero payoff to the party making the smaller investment. Thus a significant constant term arises to assure adequate monetary returns in the experiment. This explanation is refuted by the highly significant two-part rule estimated using data from the OI-EII treatment, where extreme investment differences were rare, and so use of a fully proportionate sharing rule would still provide a sizeable monetary return to both bargainers. Moreover, in Hackett (1993) I show that subjects are not choosing allocation rules to fully equalize payoffs net of investments when investments are observable.

Second, multipart rules may arise because bargainers are unsure which of the two pure sharing rules — 100 percent equal or 100 percent proportionate - are the appropriate fairness norm in the context of the laboratory incomplete contract. For example, the bargaining protocol used here is adapted from BMSS (1991), who argue that "people are equipped with rules-of-thumb that they use to settle conflicts of interest that arise in real-life bargaining situations and elsewhere, and that these rules-of-thumb embody fairness criteria or depend in other ways on salient or focal features of the environment in which they are used" (p. 315). BMSS report that the preconceived rules-of-thumb used by their participants were not too firmly established, and were frequently displaced by more sophisticated rules. Along these same lines Rabin (1992) points out "psychological evidence suggests that people do not all share notions of fairness, and — more importantly - they select notions of fairness that tend to justify pursuing their own material interests" (p. 11-12). Finally, Guth (1992) argues that individuals themselves may engage in an internal conflict over whether equity or selfish considerations should be applied to a particular situation. Thus the estimated linear combination of the two pure sharing rules may reflect compromise over two (possibly self-serving) fairness norms whose distributional conseqences vary under conditions of investment heterogeneity. Compromise can occur through the give-and-take of proposal and counterproposal.

Third, multipart surplus sharing rules may arise because individuals have utility over equitable surplus allocations, which places an upper and lower bound on feasible shares. As argued by (psychological) game theorists such as Geanakoplos, Pearce, and Stachetti (1989) Rabin (1992), an individual's outside option payoff includes the utility derived from rejecting surplus share proposals that are seen to be unfair, even if the material gain in the proposed surplus share exceeds the material gain in the outside option. This is the only outside option payoff available in the laboratory incomplete contract in equilibrium. These outside option payoffs imply a credible minimum surplus share. Bargainers can signal their minimum acceptable share through the give-and-take of proposal and counterproposal, since rejection of a given proposal is more costly (in terms of a given probability of breakdown and subsequent seller veto) to those with a lower preference for equitable distributions. Thus the fractional weight on a constant term in the estimated surplus sharing rule is consistent with a participation constraint on the pure proportionate rule predicted by the equity-theoretic hypothesis.

The latter two motives for multipart rules (normative conflict and utility over fairness) imply that rejection of first proposals can transmit important information, and so the extraordinarily high rate of first proposal rejection observed in this study is consistent with both of these motives for multipart rules. Moreover, the higher rate of first proposal rejection observed in the unobservable investment treatment may occur because bargainers are attempting to signal their investment level. Unfortunately it is difficult to construct a test that distinguishes between these two explanations. For example, while bargainers' initial proposals and counterproposals generally bracket the rule that is finally agreed to (about 80 percent of the time), the initial positions rarely coincide with each party proposing the pure one-part rule most self-serving. Importantly, however, both of these motives are grounded in investment heterogeneity, and neither are inconsistent with the data.

IV. CONCLUDING COMMENTS

This study offers considerable evidence that heterogeneous groups share their joint return in ways that differ substantially from the sharing rules used by largely homogeneous groups. In particular, multispeciality medical groups use equal sharing rules at a significantly lower frequency than single speciality groups, and groups that do use equal sharing rules are significantly smaller than those that use productivity-weighted sharing rules. This pattern is consistent with the large revenue-product heterogeneity across speciality types. Heterogeneity in sunk investment levels is also found to influence sharing rules in laboratory incomplete contracts, a result that is consistent with notions of equity and distributive justice, and which has implications for investment incentives.

There are a number of potentially fruitful areas for further research. For example, case study research suggests that seniority-indexed sharing rules are commonly used in group law practices, while such schemes are uncommon in group medical practices. Carr and Mathewson (1990) argue that seniority schemes are used in law to give senior partners an incentive to monitor and so protect the shared reputational capital of the partnership. It would be useful to survey a large number of law partnerships to see if indeed they generally use seniority-based sharing rules, and if so to study why this motive does not appear to be compelling in medical groups. It is possible that written legal work is inherently more easily monitored than physician services.

At a broader level, this study addresses the question of how human groups accommodate diversity, a question also posed by psychologists, sociologists, and others in social contexts that include common-pool resources and voting organizations. It strikes me that this is ultimately a multidisciplinary question, and that as Holmstrom and Tirole's suggest, economists studying contracting should integrate observations from neighboring fields such as sociology and psychology.

REFERENCES

Azevedo, D., "Can You Make Your Income-Division Formula Work Better?" Medical Economics, August 20 1990, 67.

Beck, L., "Dividing Group Practice Income," Pennsylvania Medicine, November 1972, 75, 35-7.

Binmore, K., A. Shaked and J. Sutton. "An Outside Option Experiment." Quarterly Journal of Economics, November 1989, 753-70.

____________, P. Morgan, A. Shaked and J. Sutton. "Do People Exploit Their Bargaining Power? An Experimental Study." Games and Economic Behavior, August 1991, 295-322.

Bolton, G. "A Comparative Model of Bargaining: Theory and Evidence." American Economic Review, December 1991, 1096-1136.

Carr, J., and F. Mathewson, "The Economics of Law Firms: A Study in the Legal Organization of the Firm," Journal of Law and Economics, October 1990, 33, 307-30.

Coase, R., "The Nature of the Firm," Economica, 1937, 386-405.

_________, "The Institutional Structure of Production," American Economic Review, September 1992, 82, 713-719.

Crawford, V. "Long Term Relations Governed by Short Term Contracts." American Economic Review, June 1988, 485-99.

Fama, E., and M. Jensen, "Agency Problems and Residual Claims," Journal of Law and Economics, June 1983, 26, 327-49.

Forsythe, R., J. Horowitz, N. Savin and M. Sefton. "Fairness in Simple Bargaining Experiments." Photocopy, University of Iowa, 1991.

Fudenberg, D., B. Holmstrom and P. Milgrom. "Short-Term Contracts and Long-Term Agency Relationships." Working paper 488, MIT, 1987.

Geanakoplos, J., D. Pearce, and E. Stacchetti, "Psychological Games and Sequential Rationality," Games and Economic Behavior, 1, 1989, 60-79.

Gilson, R.., and R. Mnookin, "Sharing Among the Human Capitalists: An Economic Inquiry into the Corporate Law Firm and How Partners Split Profits," Stanford Law Review, January 1985, 313-92.

Granelli, J., "It's time to Slice the Pie," National Law Journal, December 18, 1978, pp. 1,12.

Grossman, S. and O. Hart. "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration." Journal of Political Economy, August 1986, 691-719.

Guth, W. "Distributive Justice: A Behavioral Theory and Empirical Evidence." EFI Research Paper 6461, Stockholm School of Economics, Stockholm, Sweden, 1992.

______, R. Schmittberger and B. Schwarze. "An Experimental Study of Ultimatum Bargaining." Journal of Economic Behavior and Organization 3(3), 1982, 367-88.

______and R. Tietz. "Ultimatum Bargaining Behavior." Journal of Economic Psychology, September 1990, 417-49.

Hackett, S. Essays on the Economics of Contracting and Institutional Choice, unpublished Ph.D dissertation, Texas A&M University, 1989.

__________. "Incomplete Contracting: A Laboratory Experimental Analysis." Forthcoming, Economic Inquiry, 1993.

__________. "Heterogeneity and the Provision of Governance for Common-Pool Resources," Journal of Theoretical Politics, July 1992, 4, 325-42.

__________, E. Schlager, and J. Walker "The Role of Communication in Resolving the Commons Dilemma: Experimental Evidence With Heterogeneous Appropriators," photocopy, Indiana University, 1992.

Harrison, G. and K. McCabe. "Testing Bargaining Theory in Experiments," Photocopy, University of South Carolina, 1991.

Hart, O. and J. Moore. "Incomplete Contracts and Renegotiation." Econometrica, July 1988, 755-86.

______and B. Holmstrom. "The Theory of Contracts," in T. Bewley, ed., Advances in Economic Theory, Fifth World Congress, Cambridge: Cambridge University Press, 1987.

Hoffman, E. and M. Spitzer. "The Coase Theorem: Some Experimental Tests." Journal of Law and Economics, April 1982, 73-98.

__________and__________. "Entitlements, Rights, and Fairness: An Experimental Examination of Subjects' Concepts of Distributive Justice." Journal of Legal Studies, June 1985, 259-97.

_________, K. McCabe, K. Shachat, and V. Smith, "Preferences, Property Rights and Anonymity in Bargaining Games," photocopy, University of Arizona, 1991.

__________and J. Tirole. "The Theory of The Firm." in R. Schmalensee and R. Willig, eds., Handbook of Industrial Organization, Amsterdam: North-Holland, 1989.

Holmstrom, B., and P. Milgrom, "Aggregation and Linearity in the Provision of Jutertemporal Incentives," Econometrica, March 1987, 55, 303-28.

Kandel, E. and E. Lazear, "Peer Pressure in Partnerships," Journal of Political Economy, August 1992, 100, 801-17.

Klein, B., R. Crawford and A. Alchian. "Vertical Integration, Appropriable Rents, and the Competitive Bidding Process." Journal of Law and Economics, October 1978, 297-326.

Macaulay, S. "Non-Contractual Relations in Business." American Sociological Review, February 1963, 55-70.

Macnell, I. "Contracts: Adjustment of Long-Term Economic Relations Under Classical, Neoclassical, and Relational Contract Law." Northwestern University Law Review, 1978, 72, 854-905.

McKay, N., "The Economic Determinants of Speciality Choice by Medical Residents," Journal of Health Economics, 1990, 9, 335-57.

Milgrom, P. and J. Roberts. "Bargaining and Influence Costs and the Organization of Economic Activity." in J. Alt and K. Shepsle, eds., Positive Perspectives on Political Economy, Cambridge: Cambridge University Press, 1990.

Mitchell, J., and J. Sunshine, "Consequences of Physicians' Ownership of Health Care Facilities — Joint Ventures in Radiation Therapy," New England Journal of Medicine, November 19, 1992, 327, 1497-1501.

Neelin, J., H. Sonnenshein and M. Spiegel. "A Further Test of Noncooperative Bargaining Theory: Comment." American Economic Review, September 1988, 824-36.

Ochs, J. and A. Roth. "An Experimental Study of Sequential Bargaining." American Economic Review, June 1989, 355-84.

Rabin, M., "Incorporating Fairness Into Game Theory and Economics," Photocopy, University of California, Berkeley, 1992.

Ross, A., S. Williams and E. Schafer, Ambulatory Care Organization and Management, New York: John Wiley and Sons, 1984.

Rubinstein, A. "Perfect Equilibrium in a Bargaining Model." Eeonometrica, January 1982, 97-110.

Simon, H., "A Formal Theory of the Employment Relationship," Econometrica, 1951, 19, 293-305.

Stahl, I. Bargaining Theory, Stockholm: Economics Research Institute, 1972.

Swedlow, A., G. Johnson, N. Smithline, and A. Milstein, "Increased Cost and Rates of Use in the California Workers' Compensation System as a Result of Self-Referral by Physicians," New England Journal of Medicine, November 19, 1992, 327, 1502-1506.

Tirole, J. "Procurement and Renegotiation." Journal of Political Economy, April 1986, 235-59.

__________. The Theory of Industrial Organization. Cambridge: MIT Press, 1988.

Wiggins, S., S. Hackett, and R. Battalio, "Imperfect Information, Multilateral Bargaining, and Unitization: An Experimental Analysis," Photocopy, Indiana University, 1991.

Williamson, O. Markets and Hierarchies. New York: Free Press, 1975.

Appendix: Instructions and Questionnaire for the Equal Investment Incentives Treatment

This is an experiment in the economics of decision making. The funding for this experiment has come from a number of sources, including Indiana University. The instructions are simple, and if you follow them carefully and make good decisions, you may earn a considerable amount of money that will be paid to you in cash at the end of the experiment. The experiment takes place on the computer, but you do not need to have any specialized knowledge of computers in order to successfully participate in this experiment. Any attempt at communicating with other participants verbally or in any way other than through the computer is grounds for being REMOVED from the experiment.

The experiment consists of a series of periods. Each period the computer will randomly match one participant with another to form independent decision making pairs. Once participants have been matched, the computer will randomly choose one of participant to have the status of a "buyer"; the other participant will then have the status of a "seller." You are equally likely to be chosen a buyer or a seller. You will not know the other party's identity.

In this experiment each buyer and seller decision-making pair must make a series of decisions regarding the implementation of a PRODUCT IMPROVEMENT. Your payoffs depend on the type of decisions that are made by you and by the participant that you have been matched with in a given period. The following is a step by step summary of the sequence of decisions you will be confronted with each period:

I. INVESTMENT DECISION

Buyers can invest some of their earnings in increasing the VALUE (V) of the product improvement; similarly, sellers can invest some of their earnings in decreasing the COST (C) of providing the product improvement. The investment process proceeds as follows.

At the time the investment decision is made, the cost C and the value V of the product improvement are not known. Specifically, the value of the product improvement will be either $5 or S3. Buyers will have an opportunity to invest some of their earnings to increase the PROBABILITY (X) that V will be $5 rather than $3. Similarly, the cost C will be either $0.50 or $2.50, and sellers will have an opportunity to invest some of their earnings to increase the PROBABILITY (Y) that C will be $0.50 rather than $2.50. The computer uses X and Y in the following way when it randomly chooses V and C:

Suppose a buyer decided to invest enough earnings to raise X up to 30 — a 30% probability that V is $5 rather than $3. The computer will then randomly draw a number, and any number between 0 and 100 is equally likely to be drawn. If the number drawn by the computer is between 0 and 30, then V = $5; on the other hand, if the number drawn by the computer is between 31 and 100, then V is $3. The more earnings the buyer invests the larger is X, and so the larger is the probability that V = $5 rather than $3.

Similarly, suppose a seller decided to invest enough of her earnings to raise Y up to 75 — a 75% probability that C is $0.50 rather than $2.50. If the number drawn by the computer is between 0 and 75, then C = $0.50; on the other hand, if the number drawn by the computer is between 76 and 100, then C is 32.50. The more earnings the seller invests the larger is Y, and so the larger is the probability that C = $0.50 rather than $2.50.

The amount of earnings needed to increase X and Y will be illustrated to you on the

The amount of earnings needed to increase X and Y will be illustrated to you on the computer following these instructions. Attar the buyer chooses X and the seller chooses Y, the computer will show the values of X and Y, as well as the values of V and C, to both parties.

II. SHARING DECISION

Ones V and C are made known to the buyer and the seller, they can choose to share the GROSS RETURN (V - C) - the difference between the value and the cost of the product improvement. Note that the expense incurred by the buyer in increasing X, and the expense incurred by the seller in increasing Y, are sunk costs that are paid regardless of how (V - C) is shared.

The gross return (V - C) can only be shared if both the buyer and the seller agree. If they both agree, then the buyer and the seller will alternate making share offers until EITHER an offer is accepted, OR negotiations break down. In odd-numbered periods buyers will offer first, while in even-numbered periods sellers will offer first.

When it is your turn to make a share offer, then the other person has the choice of accepting or rejecting your offer. The total number of share offers that can be made by you and the other parry is limited, and has been fixed in advance. Each time an offer is rejected, there is a chance that no more share offers will be allowed, and negotiations will be ended without (V-C) having been shared. The maximum number of share offers that can be made may be large or small, and will usually be different from one period to the next. You should reckon that there is a 90 percent chance that at least one more share offer can be made.

Buyers and sellers can make any share offer which adds up to 100 percent. If negotiations break down, then the buyer gets V, and the seller pays C.

EXAMPLE: suppose that V = $5 and C = $0.50, so that (V - C) = $4.50. Unless BOTH the buyer and the seller agree to share (V - C), the buyer will get V = $5, and the seller will have C = $0.50 deducted from her earnings. Suppose instead that they agree to share, and the buyer made a share offer of 33 — the buyer was willing to take 33 percent of (V - C) = $1.50, and so give the seller 67 percent of (V - C) = $3. If the seller accepts this offer, that is how the gross return will be shared.

III. VETO DECISION

After the sharing decision has been made, EITHER the buyer OR the seller can decide to stop ("veto") the product improvement. If either the buyer or the seller vetoes, then the value of the product improvement V = $0, and the cost of the product improvement C = $0.

IMPORTANT ISSUES:

1. FORECASTING

At the time you choose X or Y, you will always know how much it costs you to choose different levels of X or Y. On the other hand, the money payoff that you can expect to receive depends on your forecast of what the SHARING and VETO decisions will be. In order to provide you with your FORECASTED PAYOFF, you will be asked to enter your forecast of (i) whether you and the other party will SHARE (V-C), and if so, what share you will receive, and how much investment in X or Y the person you are matched with will make, and (ii) whether the product improvement will be VETOED.

2. NET PAYOFFS
Net payoffs each period are computed as follows:

If the product improvement is NOT vetoed:

A. If (V - C) was shared:

BUYER PAYOFF = share*$(V-C) - $(investment in X)
SELLER PAYOFF = (1-share)*$(V-C) - $(investment in Y)

B. If (V - C) was not shared:

BUYER PAYOFF = $V - $(investment in X)
SELLER PAYOFF = -$C - $(investment in Y)

If the product improvement IS vetoed:

BUYER PAYOFF = -$(investment in X)
SELLER PAYOFF = -$(investment in Y)

You will have a starting balance of $4 at the beginning of the experiment. Your new balance each period will be your previous balance, plus you net payoffs that period. Net payoffs can be negative, and if your balance falls below $0, you will be removed from the experiment.

If you have any questions, you can enter "R" to re-read the instructions, or you can raise your hand.

Questionnaire

X	Y	COST OF X or Y
0	0	$0.00
10	10	$0.01
20	20	$0.04
30	30	$0.09
40	40	$0.16
50	50	$0.25
60	60	$0.36
70	70	$0.49
80	80	$0.64
90	90	$0.81
100	100	$1.00

This table illustrates how much of your earnings you must invest to increase the probability X or Y. Use this information for the questions below.

1. Pick an X for a buyer, and a Y for a seller.

   X = ______, cost of X = $______; Y = ______, and cost of Y = $______

2. Suppose that the computer randomly picks the number 47. If the X you picked is 47 or larger, then V = $5; otherwise V = $3. If the Y you picked is 47 or larger, then C = $0.50; otherwise C = $2.50.

3. Calculate V, C, and (V - C) based on the information in #2 above.

   V = $________, C = $________, (V - C) = $__________.

4. a. Suppose that (V - C) is NOT shared, and the product improvement is NOT vetoed. Then the buyer's and the seller's net payoffs are:

   buyer: $_________ seller: $_________.

   b. Suppose that (V - C) is NOT shared, and the product improvement IS vetoed. Then the buyer's and the seller's net payoffs are:

   buyer: $_________ seller: $_________.

   c. Suppose that (V - C) IS shared, and the product improvement is NOT vetoed. Pick a way to split (V - C):

   buyer share = _______% seller share = _______%.

   buyer's net payoff = $_________; seller's net payoff = $_________.

   d. Suppose that (V - C) IS shared as you picked in c. above, but the product improvement IS vetoed. Then calculate

   buyer's net payoff = $_________; seller's net payoff = $_________.

Table 1

Rate of Equal Sharing by Group Speciality Type

Group Type	Number of Groups	Percent Using 100% Equal Sharing Rule	Significance of Wicoxon Two-Sample Test Against Multispeciality Group Sample
All Multispecialty	506	4	---
All Single Specialty	758	35	.0001
Single Specialty Breakdown:			
Psychiatry	15	7	.61
Otolaryngology	21	14	.33
Family Practice	103	15	.01
Ophthalmology	49	16	.45
Internal Medicine	113	19	.0001
Orthopedics	168	27	.0001
General Surgery	22	36	.01
Cardiology	35	37	.0001
Pediatrics	22	41	.0001
OB/GYN	52	44	.0001
Misc. Surgery	13	46	.004
Cardio/Thor/Vasc	26	46	.0001
Urology	17	53	.0001
Anesthesia	21	71	.0001
Radiology	70	99	.0001
Pathology	11	100	.0001

Table 2

Equal Sharing And Group Size

Group Type	Frequency of Equal Sharing Groups	Mean Number of Physicians in Equal Sharing Groups	Mean Number of Physicians in Productivity Indexed Groups	Significant at 5% level*?
Full Sample	288/1264	7.86	16.75	yes
All Multispeciality	20/506	14.5	26.97	yes
All Single Speciality	268/758	7.37	6.61	yes
Breakdown:				
Psychiatry	1/15	5	13.21	**
Otolaryngology	3/21	4.33	4.83	**
Family Practice	15/103	5.33	6.14	no
Ophthalmology	8/49	4.88	4.76	**
Internal Medicine	21/113	9.14	8.47	no
Orthopedics	45/168	5.38	5.23	no
General Surgery	8/22	6.75	9.29	**
Cardiology	13/35	5.38	6	**
Pediatrics	9/22	5.11	4.85	**
OB/GYN	23/52	4.57	5.48	no
Misc. Surgery	6/13	4.5	4.57	**
Cardio/Thor/Vasc	12/26	6.42	5.29	**
Urology	9/17	4	4.75	**
Anesthesia	15/21	14.67	28.66	**
Radiology	69/70	10.1	8	**
Pathology	11/11	--	--	--

* Based on a T-test and a Wilcoxon test comparing the sample of number of physicians in equal sharing groups to sample of number of physicians in groups using a productivity-indexed sharing rule.

** Sample size too small for reliable testing

Table 3: Experimental Design

Treatment Name	Observable Investments	Unobservable Investments	Induced Investment Incentives: Equal $V_h - V_l = \$2$ $C_h - C_l = \$2$	Strong Seller $V_h - V_l = \$.10$ $C_h - C_l = \$3$	Strong Buyer $V_h - V_l = \$3$ $C_h - C_l = \$.10$	Number of Session Repetitions
OI - EII	Yes		Yes			4
UI - EII		Yes	Yes			4
OI - SSI	Yes			Yes		3
OI - SBI	Yes				Yes	3

Figure 1: Distribution of Equal Shares Weights

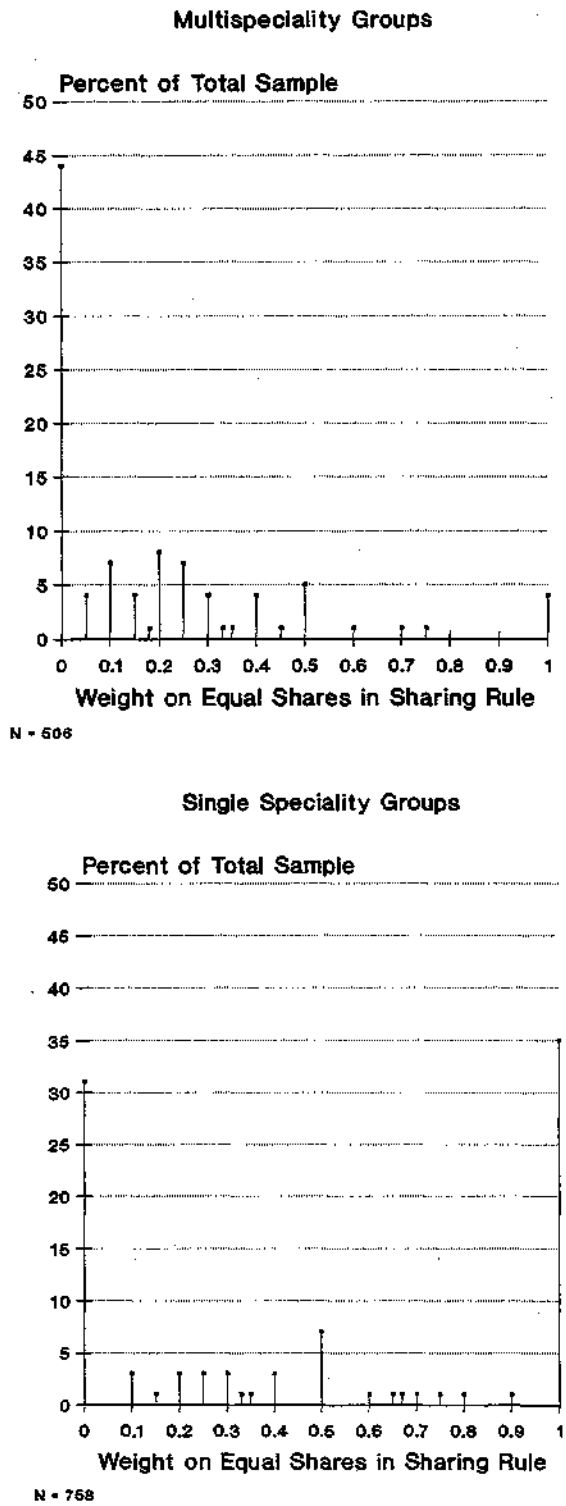
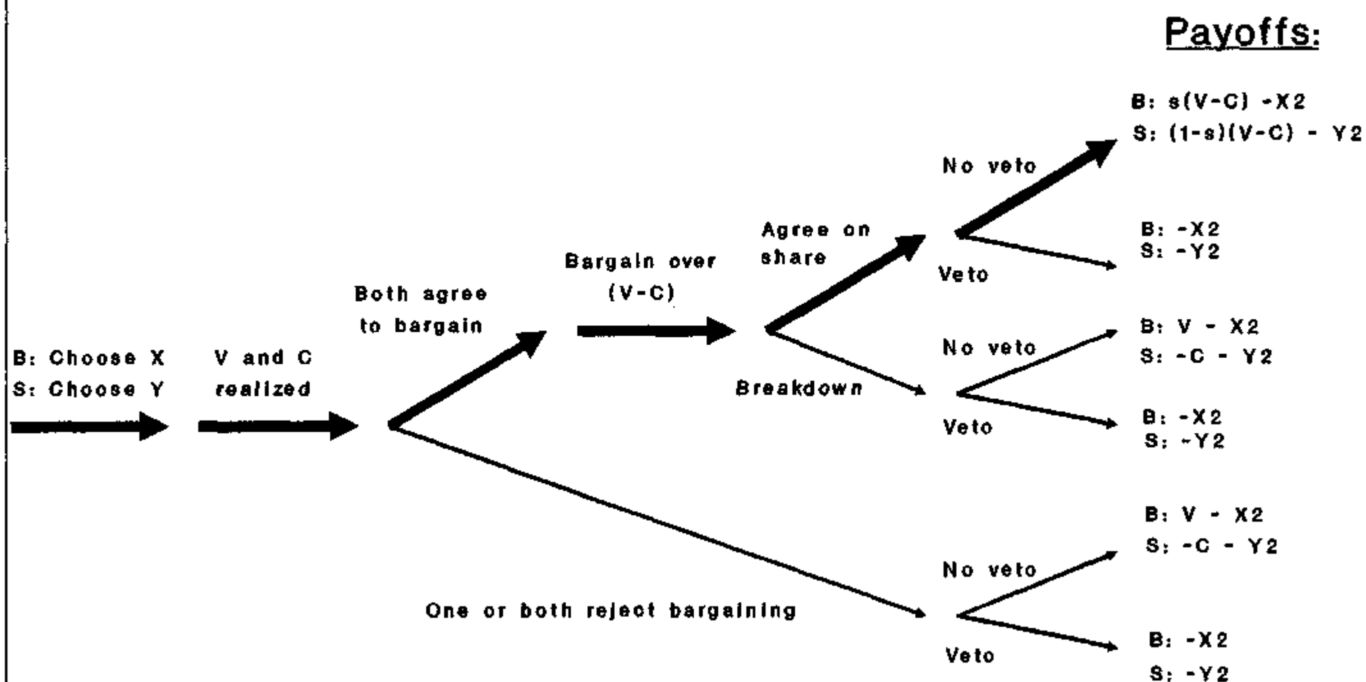


Figure 2
Incomplete Contracting Process



"B" stands for buyer, and "S" stands for seller
Bold arrows represent the equilibrium path

0

Figure 3

Surplus Sharing Outcomes, Expressed in Buyer Shares

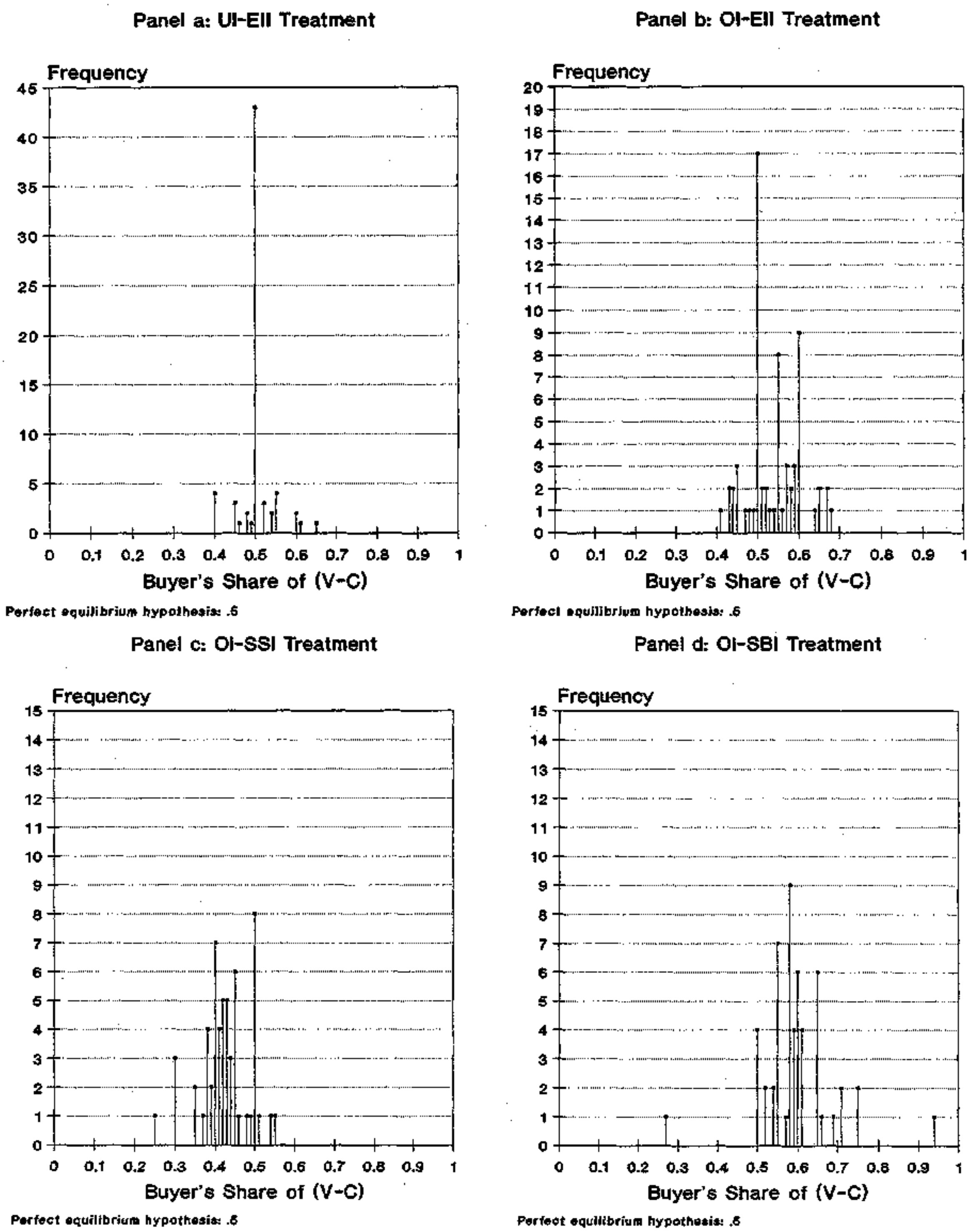
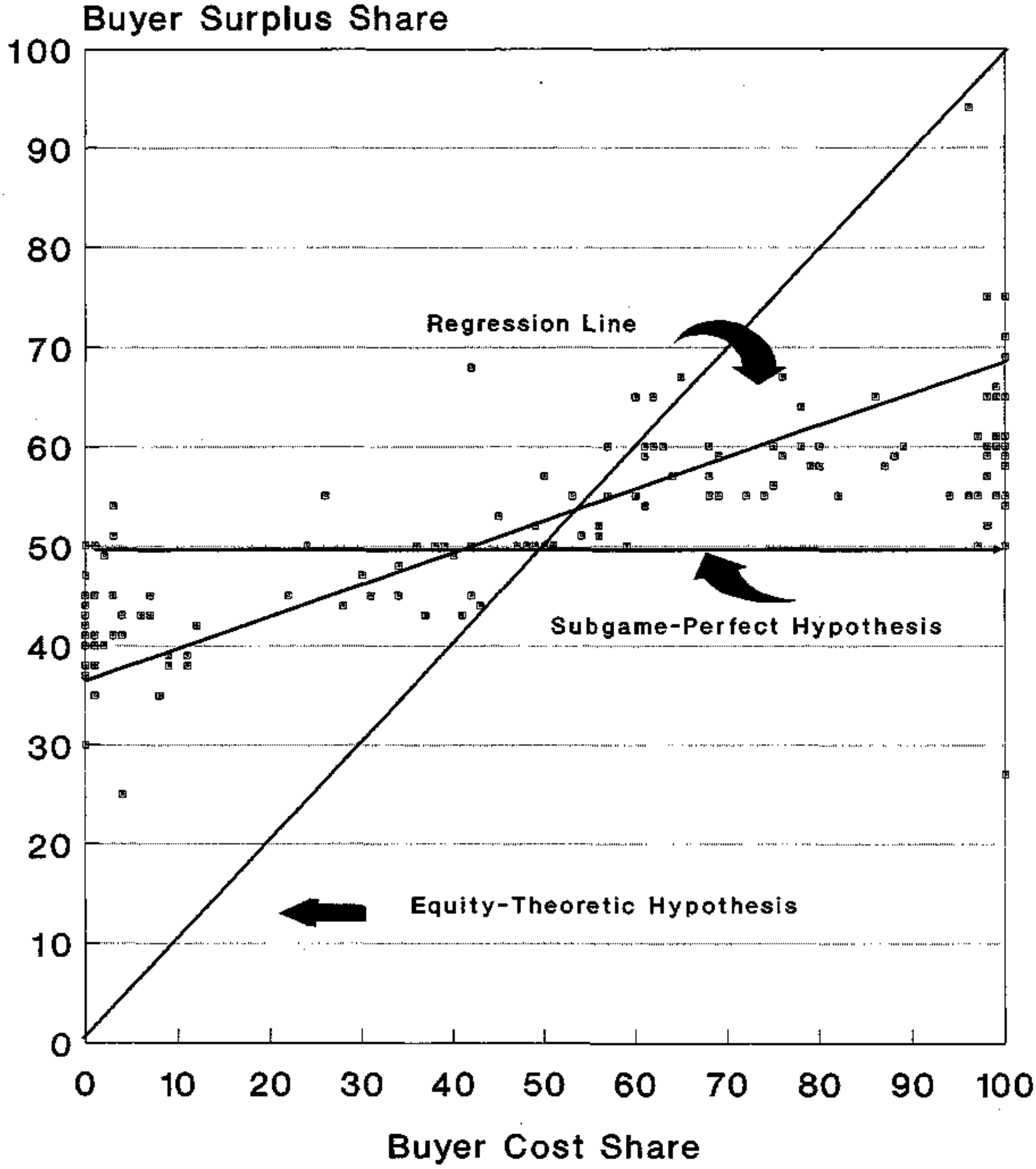


Figure 4
Buyer Surplus Share = F(Cost Share)



Ten Reps Ol Treat, All Parameterizations