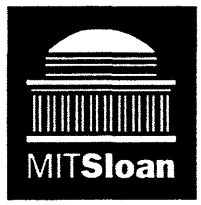

The International Center for Research on the Management of Technology

'Pie-Division' in Interorganizational Collaboration

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October 1998 **WP # 178-98**

Sloan WP # 4039

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'PIE-DIVISION' IN INTERORGANIZATIONAL COLLABORATION*

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-- Working Paper --

November 1998

* This research was supported by grants from the International Center for Research on the Management of Technology, Lean Aircraft Initiatiave, and Center for Innovation in Product Development, at the Massachusetts Institute of Technology. Special thanks to the many managers, scientists, and engineers who gave their time to share their perspectives on this process and to the students who spent many hours collecting data and readings: Carol Hwang, Dave Godes, Rishi Srivastava, and especially Christina Hsu. Thanks also to John Hauser and Nader Tavassoli for comments on earlier versions of the manuscript.

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'PIE-DIVISION' IN INTERORGANIZATIONAL COLLABORATION

ABSTRACT

Recently, there has been a growing interest in the development of collaborative relationships between organizations. Much attention has been given to how firms 'expand the pie' of benefits between them; however, there is little that addresses the ensuing issue – *how firms divide the expanded pie*. This research examines the pie-sharing phenomenon in collaborations marked by uncertainty in inputs and outputs, information asymmetries, intangible aspects, and noncomparable factors and processes. A conceptual framework is developed that examines the input, task, and organizational characteristics that facilitate the use of *equity* and *equality* sharing rules and their consequential effects on relationship outcomes. Survey results of 300 R&D managers, scientists, and engineers provide three surprising results. The first is that a simplified model of sharing is at work in these complex environments. The second insight is that it is not the case that simple rules are used as a simplifying heuristic for complex situations. Third, the judicious application of sharing rules under appropriate conditions has a significant, incremental impact on key relational outcomes. The results underscore the strategic nature of the sharing phenomenon as well as the importance of relational concerns in complex and uncertain settings.

'PIE-DIVISION' IN INTERORGANIZATIONAL COLLABORATION

INTRODUCTION

Recently, there has been a growing trend toward organizational downsizing and a renewed focus on the development of core competencies. As a result, firms find themselves having to rely increasingly on collaboration with other organizations in order to accomplish strategic ends. In the channels literature, there has been a great deal of interest in interorganizational collaboration. Most of this work addresses the facilitating conditions, or inputs, to collaboration (i.e., Anderson & Narus 1990; Morgan & Hunt 1994; Noordewier, John & Nevin 1990; Heide & John 1990); very little speaks to the *outputs* of these collaborative efforts. While some have asked, "how do we 'grow the pie' of benefits between collaborating parties?" no one has asked the ensuing question, "*how do we now divide the pie between us?*"

The issue of dividing a pie of joint benefits can be particularly difficult when there is uncertainty as to the nature and magnitude of the collaboration outcomes, information asymmetries exist, or the parties value the payoffs differently. Consider R&D collaborations, where organizations may be involved in an array of activities ranging from explorations in science and technology advancements, to directing programs of activities that develop practical competencies, to developing applied projects aimed at specific tasks. These collaborations are often formed in risky, uncertain settings around nonstandard business objectives (i.e., to learn a technology or 'keep a window' on an opportunity). It is often difficult for the parties to characterize the nature of the uncertainties that they face; they often "don't know what they don't know." Moreover, these collaborations typically involve the use of intangible inputs (i.e., expertise, tacit understandings, joint knowledge) and it is relatively difficult for each organization to evaluate the other organization's inputs, competencies, and value of outcomes.

Consider the following example. Composite Development Corporation (CDC) of West Wareham, MA, believed that composite materials could help make a superior professional hockey stick but lacked the equipment and expertise to test the idea. By collaborating with the Army Research Laboratory's Materials Directorate (ARLMD), they were able to utilize the army's material experts and the advanced prototyping and testing equipment necessary to develop the product. The result was a new technique for making constant-cross-section, high-performance composite products. The collaboration enabled CDC to test its ideas in a remarkably short time frame with minimal capital investment. With a commercial product in hand, the company was able to raise the capital needed to build an assembly line and begin marketing what has since become an internationally sought hockey stick. They have also applied their learnings from the collaboration to their parent organization, who develops windsurfing masts, booms, and bases. In turn, the ARLMD was able to advance its research in composite materials and consider new directions for application. It subsequently applied the technology to the development of low-cost launch tubes, helicopter rotor blades, bridge decks, and tent poles. In this collaboration, CDC was not able to completely predict *a priori* the gains from collaborating with the ARLMD. Because the army was so dissimilar to them, CDC may have found it difficult to evaluate the ARLMD's specific competencies, inputs, and processes.

How is sharing accomplished in collaborations characterized by complexities such as risky, uncertain settings, non-standard business objectives, noncomparable competencies, and the management of intangible inputs and outputs? What are the rules or principles used in such contexts? How do firms choose among these rules and what is their impact on critical relationship outcomes? This study was motivated by these questions. *The focus of this research is on understanding the pie-sharing phenomenon in collaborations marked by uncertainty in inputs and outputs, information, intangible aspects, and noncomparable factors and processes.*

By discovering the sharing approaches that are used in practice and observing the conditions under which the rules are used, the goal of this research is to stimulate additional thinking and investigations into this important aspect of collaboration management.

The collaborations examined in this study occur in 'noisy environments,' environments in which uncertainties regarding inputs, outputs, information, and processes create 'noise' that makes it difficult for the participants to assess and compare each party's contributions, gains, and competencies. Moreover, it is often difficult for them to characterize the nature of the uncertainties that they face. We use an R&D setting as the backdrop for our investigation, since the collaborations that occur within this realm are typified by these noisy characteristics. Although the concept of sharing outcomes among multiple participants has been investigated in various literatures, including economics, marketing, organizational theory, and psychology, much of this work is 'noiseless.' These literatures typically assume or insure that participants know what the outcomes will be, the size of the outcome, and how to assess the processes and inputs that lead to these outcomes. In many cases, each party performs specific, non-overlapping tasks such that tying one's inputs to performance is relatively straightforward. *No one has tried to test or generalize their results to more complex settings.*

In this study we examine the antecedents and consequences that surround the use of some basic sharing rules in noisy collaborations. A review of various literatures, coupled with extensive field interviews with R&D participants give rise to a set of input, process, and organizational aspects that are hypothesized to affect the use of one rule or another. Survey results of 300 R&D participants provide some surprising insights. First, the data indicates that only a few key concerns facilitate the use of one rule over another. In particular, when the inputs to the collaboration are separable or it is relatively easy to observe the other party, a complex sharing rule will be used, but when the parties value the outcomes similarly, then the pie will be

shared equally. Hence, *the data suggests a more simplified model is at work in these uncertain settings*. Second, when we investigate possible explanations for this, we find that *it is not the case that the simpler rule is used as a simplifying heuristics for complex situations*. The settings in which these rules are used do not significantly differ from the settings in which more complex rules are used. Third, we find that *the judicious application of these rules under appropriate conditions has a significant, incremental impact on key relational outcomes*. Collectively, it appears that in collaborations with high levels of uncertainty and relative ambiguity, firms strive to protect their investments and returns. Beyond this, there is also some concern that the use of these rules insure relational gains – the sense that their efforts were worthwhile, their resulting shares were fair, and they would be willing to attempt to collaborate again, should the opportunity and need arise. These results underscores the strategic nature of these collaborations as well as the importance of relational concerns in complex and uncertain settings.

Knowing how to effectively share an expanded pie among organizations has important implications for long-term relationship management and channel coordination. As more and more industries experience organizational consolidation, the number of potential collaboration partners is also diminishing. This places a growing importance on *repeated* collaborations with a few organizations. As interactions among participants are repeated, the complexity of the analysis increases; the *folk theorem* reminds us that many equilibria in a repeated game represent an equilibrium. If the collaboration participants are not satisfied with their outcomes or do not feel that they are receiving a fair share of the expanded pie, then future collaborations are undermined and less likely to occur; it also becomes increasingly difficult to build mutually beneficial relationships between these organizations. According to a recent National Science Foundation (NSF) survey, from 1995-1997, US companies invested heavily in R&D; in fact, the rate of R&D expenditures outpaced the national economy as a whole. NSF estimated that total

R&D spending reached $205.7 billion, a 6.5% increase over expenditure levels in 1996. In order to improve the efficiency of this magnitude of investments, organizations must learn to effectively manage the process and the outcomes received from this process.

The paper is organized as follows. In the following section, a conceptual framework of sharing among organizations in noisy environments is developed. Two basic approaches for sharing are highlighted: *equity* and *equality*. Although they are not exhaustive, these two approaches represent the fundamental building blocks (e.g., the Nash bargaining solution) from which more complex sharing strategies are created. This is followed by a description of the methodology for tests of hypotheses and additional analyses. The paper concludes with a discussion of results, limitations, and directions for future research.

CONCEPTUAL FRAMEWORK

In this section, a conceptual framework of facilitating conditions and relationship outcomes is developed to describe the sharing phenomenon in noisy environments. We look to the past literature for guidance, recognizing that sharing in simple versus complex settings differ in important ways, which we consider in developing our framework. As we consider the sharing phenomenon in noisy environments, it is important to consider simple rules[1] that are relatively robust to information asymmetries and yet still satisfies each party's rationality constraints. Simple rules are a useful starting point for investigations in complex environments because they are psychologically attractive (Lax & Sebenius 1986), easy to implement, and because they are often less costly than trying to resolve an indeterminate situation (Schelling 1960). Moreover, each party needs to be at least as well off with the rule as they were before the rule (i.e., Pareto optimality). An inability to characterize the uncertainty – "not knowing what you don't know" –

[1] We use the term 'rules' in the sense that they represent guidelines, approaches, or principles, for dividing up the pie.

is a dominant attribute in R&D collaborations that is not accounted for in past research on sharing. Not only do information asymmetries exist, but the parties may have no realization of how much surplus there is to be shared or what type of serendipitous circumstance or finding may occur along the way. Hence, simple rules are needed that are robust to varying information constraints and uncertainty and still leaves both participants in improved positions.

We begin with an overview of relevant work in economics, psychology, marketing, and organizational theory to identify two basic sharing rules: equity and equality. *An equity rule specifies that each member's payoffs are a function of its inputs* – tangible and intangible contributions, costs incurred, etc. -- to the collaboration. The greater one's contribution to the collaboration, the greater one's payoff. *The equality rule specifies that each party receives an equal share of the payoffs* – a 50/50 split, in this research. We then describe the facilitating conditions for the use of these rules, drawing on past research and pre-study interviews with R&D participants, and subsequently consider the relational outcomes of these rules.

Our unit of analysis is the perspective of an organizational participant in an R&D collaboration comprised of two financially independent, non-competitive organizations who each supply a complementary competency that enables the joint effort. Hence, joint ventures, networks, horizontal relationships, and vertically integrated relationships are beyond the scope of this study. Although the organizations may differ in the functions they perform, symmetry is expected in the nature and pattern of causation of the behavioral constructs that underlie their relationship.

LITERATURE REVIEW OF SHARING

Sharing outcomes among multiple participants has been investigated in several literatures, including economics, marketing, organizational theory, and psychology. Each body of literature can be arrayed in terms of the level of environmental noise examined in their

research. In economics and psychology, sharing is primarily examined as a function of different payoff structures. The work in marketing adds another level of complexity, including the need for coordination and the management of functional differences between organizations. Work in organizational theory is noisier yet – in this literature, sharing is examined among international competitors and in collaborations marked by interdependent activities and intangible inputs and outputs. We now turn to a more detailed consideration of each literature's contribution to understanding the sharing phenomenon.

Economics. In economics, there is a large literature on game theory and bargaining that examines how payoffs are allocated among parties. Komorita and Parks (1995) provides an extensive review of various types of mixed-motive interactions, including social dilemmas and coalition formations. In this work, participants are asked to allocate payoffs among multiple participants, including themselves. It is typically assumed that the players have full-information, are motivated to maximize their payoffs, and know precisely the nature or size of the pie to be divided. Other research into ultimatum behavior or dictator behavior assumes that the participants know the size and nature of the pie to be split or that one player is able to unilaterally determine the outcomes of both (i.e., Camerer & Thaler 1995). Research in negotiations has primarily centered on the roles of different types of participants (i.e., value creators vs. value claimers) and the nature of their interests (instrumental or intrinsic) in determining payoff allocations (see Lax & Sebenius 1986 for a review), but there is little examination of sharing as a manageable process. Although Komorita & Parks, along with Kahan & Rapoport (1984) and Komorita (1984), have called for theory in this literature to take a process approach, attempts in this direction have been discouraging because of the mathematical difficulties that such an approach would represent.

Psychology. While economists tend to emphasize the development of formal (axiomatic) theory in payoff allocations, social psychologists tend to emphasize cognitive-motivational approaches. Work on social dilemmas (see Dawes 1980 for a review) focuses on the factors that lead people to cooperate and how expected differences in payoffs motivate their behaviors. In this research, participants receive a higher payoff for a socially defecting choice (i.e., having additional children, using all the energy available, polluting his or her neighbors) than for a socially cooperative choice, no matter what the other individuals in society do; however, all participants are better off if they cooperate than if they all defect. This payoff structure is not generalizable to our research; in noisy environments such as R&D, the payoff for a socially defecting choice is not necessarily higher than for a socially cooperative choice.

The work on sharing in game theory, bargaining, and social dilemmas is less noisy than sharing in R&D collaborations; although information asymmetries may exist between the participants, these research areas typically assumes that participants know what the outcomes will be, the size of the outcome, and a fair distribution (which requires an ability to assess the processes and inputs that lead to those outcomes). Moreover, the primary task of the participant(s) is to make an allocation decision; rarely are they asked to engage in more complex coordination tasks in more uncertain settings. As a result, the generalizability of this research to collaboration contexts in which participants are less able to characterize the uncertainties between organizations is limited.

Marketing. As we consider research in more noisy environments, one striking aspect is the use of very simple rules despite prevailing uncertainty in inputs and outputs, information asymmetries, and intangible aspects. In marketing, Jeuland & Shugan (1983) note the use of one approach, a 50/50 equality rule for sharing. Although, their analysis does not depend on this rule, their analysis assumes perfect information and is dependent on differing incentives;

moreover, it includes the complexity of coordination among functionally different organizations. Stern, El-Ansary & Coughlan (1996) describe a different rule – the equity principle – in which channel members are granted discounts based on the functions that they perform. This enables the organizational dyad to match incentives and coordinate the channel. However, this rule requires an ability to identify discrete functions and assign a monetary value to each firm such that each party is fairly rewarded. Moreover, it is more appropriate when each channel level is distinct, serves different types of customers, and performs different functions in different markets. As the channel structure becomes more complex and the interdependence between functions increases, this approach becomes less useful. Hence, in marketing, the research on sharing is characterized by the fact that each party performs specific, non-overlapping tasks, such that tying one's performance to outcomes is relatively straightforward.

Organizational theory. In organizational theory, the collaboration contexts increase in complexity, however, we continue to observe participants relying on the simple rules of equity and equality. Moxon, Roehl & Truitt (1988) examine gain sharing in international ventures among competitors in the commercial aircraft industry. The focus of their work is on the impact of bargaining power, contract design and dynamic venture change. More closely related to our research is work on allocating credit in joint authorships (Floyd, Schroeder & Finn 1994). Joint authorship of journal manuscripts represent noisy collaborations. The outcomes are not realized until the work is accepted for publication, and the potential impact is relatively stochastic. Moreover, there is a high degree of interdependence among the functional tasks and many intangible aspects and processes (i.e., understanding of various literatures and methodology applications, research design and manuscript structuring). Floyd, et. al find that collaborators tend to use an equity sharing rule; those participants making substantial contributions toward the

joint effort are credited with authorship and research design is considered the most important task (Bridgewater, Bornstein & Walkenbach 1981; Spiegel & Keith-Spiegel 1970).

SHARING RULES

This research continues exploration of the use of *equity* and *equality* sharing rules in noisy environments. The literature in group decision-making indicates that equity sharing rules are generally used when productivity is the primary goal (Deutsch 1985; Kabanoff 1991) and is typically advocated by those with high resources (McGrath 1984). Equity principles for sharing is derived from equity theory (Adams 1965; Walster, Walster & Berscheid 1978), which states that people judge an outcome as fair when the ratio of their own inputs and outputs equals the ratio of inputs and outputs of comparison others. In our pre-study interviews with R&D participants, many informants told us that an equity sharing rule would be used to account for inputs to the task such as financial contributions, technical expertise, and asset ownership. The organization who contributed the bulk of the expertise or equipment would receive a larger proportion of the benefits gained.

In contrast, equality sharing rules entitle each member to a 50/50 split of the collaboration outcomes. This rule is typically used in groups when the priority is to maintain within-group harmony, social relationships, and dissension reduction (Deutsch 1985 & Kabanoff 1991) and is typically advocated by those with low resources (McGrath 1984). Research on this rule indicates that although it may not foster the highest levels of productivity, it does facilitate close cooperation among members; it is particularly useful when differences between various inputs are vague and hard to measure (Allison & Messick 1990; Allison, McQueen & Schaerfl 1992).

The use of one sharing rule over another is inextricably linked to the nature of the coordination task that faces the organization. The research on credit allocations in joint

authorships examines the specific components necessary in the production of a manuscript and attempts to assign meaningful weights to these aspects. In a similar manner, we explore how aspects of the collaboration -- input and task characteristics and organizational aspects – impact the use of one sharing rule over another. Although we do not delve into the specific processes of one R&D collaboration or another, we look to the pre-study interviews to help generalize the aspects of the inputs (asymmetry, separability, jointly idiosyncratic), task (process interdependence), and organizations (observability, transformation understanding, equal payoff valuations) that facilitate the use of each rule. The facilitating conditions and consequences that are examined in this research are not exhaustive of the universe of possibilities, but represent a partial test of how sharing occurs in noisy environments. If the results are robust, future research might explore other aspects of the collaboration context. We also explore the impact of the sharing rules on relational outcomes. Since there exist other research that provides an extensive consideration of metrics for R&D project success (see Hauser 1996 for an annotated bibliography), our focus is on the impact of the sharing rules on the *relationship* between organizations. We examine the degree to which the collaboration was worthwhile, the perceived fairness of the outcomes, and the likelihood of engaging in future collaborations.

FACILITATING CONDITIONS

Prior to data collection, we spent several months conducting interviews with R&D participants in order to understand their noisy collaboration environments, the sharing rules they used, and how the rules were implemented within the collaboration. The interviews with these individuals, along with a review of the aforementioned literatures, led to the identification of a number of factors that facilitate the use of the two rules in noisy environments. Broadly construed, these factors include (1) characteristics of the inputs and task and (2) characteristics of the organizations. The nature of the inputs affected the choice of sharing rules, particularly when

the inputs were asymmetric among the organizations, easily separated, or jointly idiosyncratic. The degree of interdependence in the task also influenced the type of rule used. Finally, each organization's ability to observe the other party or understand its transformation process and the degree to which both organizations valued the outcomes of the collaboration also determined the type of sharing rule that was used. We elaborate on each in turn.

Input and task aspects. When organizations input human resources, intellectual property, equipment, and funding into a collaboration, they are motivated to insure that they get a fair return on their investments. One of the ways that they insure this is to use a sharing rule that best accounts for their contributions and insures a fair share of the expanded pie. If one organization makes *asymmetric* contributions to the relationship – inputs more resources than the other party -- it will want to use an equity rule in order to assure itself a the larger portion of the expanded pie. The equity rule is an effective way to insure that the one who has made the greater contribution receives the dominant share of the outputs. When each party's inputs are *separable* – easily distinguished from the inputs of the other party – then the organizations will be motivated to use an equity rule to insure that the receive a fair return on their contributions to the collaboration. Separability refers to the ability to clearly attribute the inputs of each organization.

H1: Asymmetric inputs are positively associated with the use of an equity rule.

H2: Separable inputs are positively associated with the use of an equity rule.

Sometimes, the parties have created *joint idiosyncratic investments* (e.g., software, specific expertise and skill sets) together that are useful to the collaboration. These investments are nonfungible, in the sense that they are nontransferable to alternative collaboration arrangements and lose value if the relationship is prematurely terminated (Williamson 1985). These investments motivate the parties to remain in the relationship in order to recoup the value

of their investments. Since the investments are created together, the parties are likely to use an equality rule because it is difficult to assess each party's individual role in creating the idiosyncratic investments. Moreover, this rule promotes relationship maintenance, incenting the parties to remain in the relationship until the value of the investments are recovered. Stated more formally, we expect:

H3: Joint, idiosyncratic investments are positively associated with the use of an equality rule.

Process interdependence is a fundamental aspect of collaborative relationships. It occurs when both organizations recognize that their joint success depends in part on the other organization; hence, they engage in similar or complementary coordinated actions in order to accomplish the goals of the collaboration relationship (Anderson and Narus 1990; Dwyer, Schurr & Oh 1987; Frazier 1983; Heide & John 1992; Stern & Reve 1980). The level of interdependence among organizational roles, task aspects, and activities may vary from one collaboration to another, depending on the nature of the task and the goals of the dyad. When the collaboration process is highly interdependent, then it becomes difficult to separate each organization's efforts and behaviors in the task. Hence, an equality sharing rule becomes a simple way to jointly motivate cooperation so as to insure collaboration success.

H4: Process interdependence is positively associated with the use of an equality rule.

Organizational aspects. In many collaborations, organizations pair with other organizations who have complementary competencies or processes that enable the dyad to achieve goals and outcomes beyond each organization's individual reach (Weitz & Jap 1995). Although effective for joint success, this holds potential difficulties for sharing. When an organization is unfamiliar with the other party's competencies or processes, it becomes difficult to observe and evaluate the other party's efforts and effectiveness. Both organizations are concerned about fairness; although each is primarily concerned about individual outcomes, there

is some concern that the other party receive a fair share (Guth, Schmittberger & Schwarze 1982; Schmitt & Marwell 1972). Neither party wants the other party to receive less than a fair share, but each party also does not want the other to receive a disproportionately greater share of the outcomes (Pruitt & Rubin 1986).

This tension can be relieved in two ways. First, the more an organization is able to *observe the other party's actions*, the easier it is to observe their effort in the collaboration and determine whether their outcomes represents a fair payoff. The ability to observe the other party's processes and actions will facilitate the use of an equity rule, as it insures that each party's outcomes are in accordance with their efforts. Second, *an ability to understand the other party's transformation process* – how the party converts inputs to outputs – enables an organization to map a reasonable expectation of the payoff to the collaboration *ex ante*. Hence, this may encourage the use of an equity sharing approach, because it provides an assurance that each party's outcomes fairly reward the value of it's transformation process. Alternatively, it may be that an organization has a holistic understanding of the transformation process, but is not able to appropriately assess the value of every aspect. In this case, the organization may prefer to use an equality rule, because of the impossibility of better understanding the transformation process. Hence, an understanding of the other party's transformation process may lead to the use of either rule.

H5: The ability to observe the other party's actions is positively associated with the use of an equity rule.

H6: Understanding of the transformation process is positively associated with the use of an equity and equality sharing rule.

Equal payoff valuation. Each organization enters into a collaboration with the hope of achieving some type of desired end – patents, reduced time to market, control over future technologies, potential commercial applications, etc. In some collaborations, both organizations may value these benefits similarly (e.g., they both want to produce joint patents or jointly control

future technologies). In other collaborations the parties may place dissimilar values on various outcomes. When both organizations *value the outcomes of the collaboration similarly*, an equality sharing rule is more likely to be used than an equity rule. An equality rule will incent both parties to cooperate closely in order to achieve desired ends, whereas an equity rule would require tracking efforts that may be unnecessary for dividing up the pie.

H7: Equal payoff valuations is positively associated with the use of an equality rule.

RELATIONSHIP OUTCOMES

Much of the past research on sharing focuses on each party's maximization of its individual outcomes. While this is admittedly of value, research on sharing should also consider how the use of these rules impacts the *relationship* between the participants, because enhancement of the relationship may have a significantly greater impact on their *joint* utility. How the sharing process impacts the relationship also carries long-term ramifications. In many industries, consolidation among firms is reducing the number of alternative organizations to collaborate with. As a result, many organizations need to work with each other on a repeated basis. If organizations act opportunistically in the short-term, they may develop a negative reputation that will inhibit other firms from working with them in the future. Hence, it is important that organizations in collaborations learn to apply equity and equality rules in a manner that create relationships that foster satisfaction with the collaboration, a sense of fairness in the outcomes, and a willingness to collaborate again in the future.

Satisfaction with the collaboration is a positive affective state resulting from the appraisal of all aspects of a working relationship. In the literature on channel relationship management research, it is one of the most studied outcome variables (see Gaski 1984 for a review) and an important indicator of the impact of the collaboration process on the relationship. In the discussion of the facilitating conditions to the sharing rules, we noted that organizations are

motivated to receive fair outcomes. *Outcome fairness* is the organization's perception that it has received a fair share of the divided pie of outcomes, benefits, and gains from the collaboration. Our final outcome measure is *willingness to collaborate in the future*. This indicates the degree to which an organization would welcome the possibility of collaborating again, should the opportunity arise. The use of sharing rules – equality or equity – can impact an organization's satisfaction with the collaboration, perceived fairness of its outcomes, and willingness to collaborate in the future.

Sharing rules are a means by which organizations reduce noise in their environment; without them, there remains uncertainty as to what each party's share of the final pie will be. This effect is even more pronounced when the parties are unable to predict what the outcomes from the collaboration will be. In R&D, the gains from collaboration can often be serendipitous. Work in relative deprivation theory (e.g., Crosby, 1976; Stouffer, Suchman, DeVinney, Star & Williams 1949) argues that people judge outcomes as unfair when the outcomes they receive fall short of their expectations. By clarifying outcome allocations via the use of sharing rules, the parties can mitigate this possibility. Moreover, the use of sharing rules provide an assurance that an attempt has been made to insure fair payoff shares for the participants. Because of this, we expect the use of these rules to facilitate satisfaction with the collaboration, perceived fairness of the outcomes received, and willingness to collaborate in the future.

H8: Equity and equality sharing is positively associated with satisfaction with the collaboration, outcome fairness, and willingness to collaborate in the future.

METHOD

PRE-STUDY INTERVIEWS IN RESEARCH CONTEXT

Prior to collecting data, we conducted depth interviews with 31 managers, engineers and scientists from the R&D divisions of a military federal research organization, a car

manufacturing firm, a telecommunications company, a chemical manufacturer, and a petroleum manufacturer, each of whom were industry leaders in their respective markets.[2] The purpose of these interviews was to understand the collaboration context, language, internal and external demands, nature of the tasks, and relevance of our measures to their experience. Our intent was to design a survey instrument in the language of the informants, drawing upon their experience, in order to elicit responses which accurately reflected the organization's viewpoint (Campbell 1955). Each informant described their perceptions of how the outcomes of R&D collaborations were shared in a variety of short- and long-term collaborations. They also discussed their a priori goals and expectations, inputs, and outcomes achieved. Their descriptions of the sharing rules were distillable into the use of equity and equality rules. In some cases, they would describe the use of a series of rules,[3] but in virtually every case, equity and equality were commonly cited as the fundamental building blocks for more complex sharing strategies. We also used these interviews and subsequent pretesting efforts as the basis for developing our measures.

DATA COLLECTION

Characteristics of the sample. We solicited questionnaire participation from the R&D departments of five organizations in the United States: (i) a federal research laboratory (the same one that participated in the pre-study interviews), (ii) a military and commercial aircraft jet manufacturer (annual sales of $52 billion), (iii) a manufacturer of aerospace concerns: commercial aircraft, defense systems and space systems (annual sales of $45 billion), (iv) a tire manufacturer (annual sales of $14 billion), and (v) a steel bearing manufacturer (annual sales of $2 billion). All of the four manufacturing organizations were leaders in their respective

[2] All of the participating organizations in this research have requested that their identities be kept confidential.
[3] For example, a collaboration may begin first with an equity rule and after a period of time migrate to an equality rule, or vice-versa.

industries. Each organization was offered a report of overall results and some customized analyses for their internal purposes. Collectively, the four manufacturing organizations contributed approximately 17% (n=130) of the respondents who were surveyed.

The federal research laboratory provided the names of 648 points of contact for R&D collaborations conducted between 1992-1997. These R&D collaborations were explicitly created to exploit potential technology transfers between the federal laboratories and the commercial sector. In these arrangements, a federal R&D division worked with a non-federal organization and each party contributed personnel, expertise, and facilities or equipment toward a mutual problem of interest. These collaborations were not procurement transactions -- the federal organizations were not allowed to contribute monetary funds; hence, the agreements were mutual endeavors that required joint effort and cooperation from both organizations. The collaborations were mutually negotiated, even in the sharing aspects. There were no specific sharing algorithms or contracts imposed upon the parties in these collaborations. Intellectual property created by the collaboration could be employed by the firms for commercial purposes, while the government might retain a license to use the technology advancement for its own purposes as well.

Collectively, 778 surveys were mailed to the respondents at the five organizations. A total of 299 surveys were returned (a 38% response rate overall).[4] Of these, 161 were from commercial organizations, while 138 were from federal organizations. The referent collaborations in the sample lasted an average of 2.1 years (sd=2.8). Respondents came from various areas of R&D: 118 were managers, 66 were scientists, 106 were engineers, and 4 were staff. The respondent's knowledge of key aspects of the collaboration was assessed via a battery

[4] The average response rate from respondents at the four firms was 50%, while the response rate from the federal research laboratory respondents was 36%.

of specific items at the conclusion of the survey (cf., Cusumano & Takeishi 1991). Respondents were asked to indicate how knowledgeable they were regarding: the intended goals and purpose of the collaboration, each organization's inputs to the collaboration, the overall success of the collaboration, and the outputs of the collaboration. They marked their response using a 7-point Likert scale (1=hardly knowledgeable, 7=very knowledgeable). The mean response to these items was 6.3 (sd=.82).

Collaboration types. We included a categorical measure in our questionnaire to assess the types of R&D collaborations reported on by the respondents; the complete measure and associated frequencies is displayed in the appendix. Respondents were asked to classify their collaboration along the 'tiers of R&D' as described by Hauser & Zettelmeyer (1995). These tiers describe various types of research endeavors ranging from basic research that lays the foundations for additional R&D (tier 0) to routine engineering for continuous improvement of products and processes (tier 4). We examined the validity of this measure extensively in our pretest efforts and found no evidence that respondents had any difficulty understanding the descriptions or classifying their work along the tiered structure. Over 70% of the sample described themselves as working on tier 2 and 3 levels of research. Tier 2 research includes directed programs of activities to develop practical competencies that support or fulfill an organization's strategic directions, while tier 3 research comprises applied projects aimed at specific tasks.

Context noise. Several measures were included to assess the 'noise' in the collaboration environments. We used a two-item measure adapted from Achrol & Stern (1988) to assess the level of *dynamism* in the collaboration environment. These items tapped changes in technology practices and competitor strategies that occur frequently and are difficult to predict; the mean response to this item was 5.3 (1.1 sd) on a 7-point scale. We also examined *the nature of each*

party's inputs, displayed in Table 1. Respondents were given a listing of various types of inputs to a collaboration and asked to checkmark those that were contributed by each organization. Complex and intangible inputs such as skills and expertise, human resources and intellectual property were checkmarked by 53-86% of the respondents. Finally, we examined *the nature of the benefits gained by each party*, displayed in Table 2. Respondents were given a listing of various types of R&D collaboration benefits and asked to checkmark those that were gained by each organization. This table indicates that the most cited benefits (for 50-80% of the sample) were complex outcomes such as understanding or knowledge, reputation enhancement, technology application, resource leveraging, test results, relationship solidification, and exposure to future technology developments. The inputs and outputs in these collaborations are 'noisy' in the sense that they are not easily translated into a common metric or comparable to each other. Collectively, it appears that the sampled collaborations are occurring in the type of collaboration environment consistent with our conceptual framework.

Procedure. Questionnaires were mailed to respondents along with a postage-paid envelope and cover letter from the researchers explaining the purpose of the study. This cover letter told them that they had been randomly selected from the participating organization's list of collaborative relationships to participate in a university study designed to better understand R&D collaborations. The respondents were guaranteed anonymity of their responses and offered a summary report in exchange for their participation.

Respondents from the federal research organization were provided the name of a specific collaboration that they worked on and were asked to complete all items with respect to that particular collaboration. Respondents from the manufacturing firms were asked to consider a recent collaboration and complete all items with respect to that particular collaboration. They were specifically told that the selected collaboration, "does not have to be a highly successful or

complex collaboration, although it may be. We are trying to sample from a variety of relationship types and would like to consider many possibilities." In this way, we were able to insure that we had the heterogeneity necessary to capture statistical variation among our constructs and increase the representativeness of the relationships studied.

QUESTIONNAIRE DEVELOPMENT

All of the constructs were measured with multiple item, 7-point Likert scales, according to the recommendations of Nunnally (1978). These scales were designed specifically for this research; at the time of the questionnaire development, we were not aware of any known scales that measured our constructs of interest. Pretests with a select group of respondents from various types of organizations and backgrounds were iterated throughout the questionnaire development; the results of each round of pretests were incorporated into a revised questionnaire and pretested on a new group of R&D participants. A list of the items and scale reliabilities are listed in the appendix. Unless stated otherwise, the anchors for all items were "1=strongly disagree" to "7=strongly agree." Table 3 exhibits the means, standard-deviations, and correlations between the constructs.

Nomological validity of equity and equality scales. Because of the critical role of the equity and equality sharing rules in our conceptual framework, some additional measures were included in the questionnaire to assess the nomological validity of these scales. We measured relational norms in the collaboration, using items from Heide and John (1992) and Dwyer and Oh (1988). Three scales of three items each measured aspects such as flexibility, solidarity, and participation. These norms are expectations about behavior that are partially shared by the organizations and directed toward collective goals. Previous research in group psychology suggests that the equality rule is used to promote within-group harmony, social relationships, and dissension reduction (Deutsch 1985 & Kabanoff 1991). As such, we would expect the equality

rule to be more strongly correlated with relational norms[5] than the equity rule. The correlation between the equality rule and relational norms was .38 ($p<.001$), while the correlation between the equity rule and relational norms was only .21 ($p<.001$).

We also assessed the degree to which the pattern of reported inputs and benefits corresponded to the use of equity and equality rules. We did this using subsamples of respondents located in the upper quartile of the distribution of mean responses to the two rules. For respondents in the top 25% of the distribution of responses to the equity scale, we examined the correlation between their reported inputs and outputs from the collaboration (listed in tables 1 and 2). If the organizations were using an equity rule for sharing, we should expect to see a significant positive correlation.[6] We coded the value of each input and output to be 1 if checkmarked, and 0 otherwise and then computed a mean input and output value. The correlation between each respondent's reported input average and output average was .32 ($p<.001$). The correlation between each respondent's report of the other party's input and output average was .37 ($p<.001$). These correlations suggest that there is a positive and significant association between each party's inputs and outputs, as suggested by the equity rule.

Similarly, we examined perceptions in the upper quartile of the distribution of responses to the equality sharing scale. For each benefit listed in Table 2 we assigned a 1 if the benefit was checkmarked, 0 otherwise. The mean of responses for the respondent's organizational gains was .42, while their perception of the other organization's gains was very similar: .40. We also asked the respondents to specify what percentage of each benefit was allocated to their organization and what percentage was allocated to the other organization. On average, the respondent's organization was allocated 49.1% of the gains, while the other organization was

[5] This was construed as the mean of the solidarity, participation, and flexibility scales.
[6] This is necessary, but not sufficient evidence for the use of an equity rule.

allocated 47.2% of the pie. The differences between the gains that each organization received and the percentage allocation of these gains appears to be minimal, which is consistent with the use of an equality rule.

MEASUREMENT ESTIMATION

Confirmatory factor analysis (CFA) techniques are used to estimate a measurement model comprised of twelve first-order, latent factors and intercorrelations. These models are estimated using full-information maximum-likelihood (FIML) in LISREL 8.03 (Jöreskog & Sörbom 1993). Each of the 37 observable indicators loaded significantly (alpha=.001) on their intended factors, indicating convergent validity among the items of each scale. The item loadings and measurement errors are in acceptable ranges; these values are listed in the appendix. Discriminant validity between the scale measures was assessed using the stringent test of Fornell & Larcker (1981). This involves examination of the amount of variance extracted by each construct (taking measurement error into account) relative to the squared-correlation between pairs of constructs. This is considered to be a more stringent test of discriminant validity than Campbell (1959) or Jöreskog (1971) because it recognizes the possibility that measurement error can vary in magnitude across items. All possible pairs of factors passed the Fornell & Larcker test, evidencing discriminant validity between the measures.

The overall chi-square for the model is 1004.1 with 563 degrees of freedom (df). Three fit indices – the comparative fit index (CFI), incremental fit index (IFI), and the Tucker-Lewis fit index (TLI) are examined; their values are .93, .93, and .91 respectively. Since high fit indices can also give the false impression that the model explains much when it really is the result of freeing more parameters to be estimated from the data, a useful index to consider is the root mean square error of approximation (RMSEA). This is a parsimony measure that accounts for potential artificial inflation due to the estimation of many parameters. Values between .05 to .08

are indicative of a satisfactory fit of the model in relation to its degrees of freedom, while values of .05 and below are indicative of a close fit (Steiger 1980; Steiger & Lind 1980). The RMSEA of the measurement model is .052. Hence, we conclude that the scale measures are internally consistent, able to discriminate, and provide a good fit of our model to the data.

STRUCTURAL MODEL ESTIMATION

Model specification. The conceptual model is also estimated using the covariance matrix of observable indicators and FIML techniques in LISREL 8.03. The structural model for the estimation process is depicted in Figure 2. The following sets of intercorrelations are estimated: (i) between facilitating conditions, (ii) between outcome factors, and (iii) between the sharing rules to account for the fact that these aspects are likely to be related in the research context. The estimated structural model has a chi-square statistic of 1163.1 (590 df) with CFI=.91, IFI=.91, TLI=.89, and RMSEA=.057. Collectively, these indicate a good fit of the model to the data.

Rival specification. The structural model examines specific relationships between the facilitating conditions and each of the sharing rules; generally, each condition is hypothesized to affect one of the two rules. An alternative specification might be that a facilitating condition should affect both rules simultaneously. We examined this possibility via the estimation of a series of nested models in which the specific parameter is freely estimated on the other rule (in addition to the hypothesized rule) and a Likelihood ratio (LR) test is used to examine the consequential impact on model fit. None of these alternative specifications had a significant impact on model fit; none of the RMSEA and fit indices changed as a result of the additional specification. Evidently, allowing the facilitating conditions to freely affect an alternative rule does not provide a better explanation of the data.

Mediation. The structural model also depicts the sharing rules as having a mediating role, such that the facilitating conditions impact relationship outcomes indirectly through the

rules. We consider the viability of this assumption by comparing it to an alternative, nested specification in which the facilitating condition is allowed to directly impact the relationship outcome. If the original effect of the facilitating condition on the rule remains significant and has a greater effect than the additional parameter, this suggests that the facilitating condition is mediated by the sharing rule (cf., Baron & Kenny 1986). The investigation of this alternative specification was supportive of mediation. The additional parameter between each facilitating condition and relationship outcome had no impact on improving the model's ability to explain the data. When the original parameter was significant and the additional parameter was significant (this happened in two cases), the original parameter remained significant and the coefficient for the additional parameter was half the size of the original parameter. The overall fit of the model was not significantly impacted in any way. Collectively, it appears that there is empirical support for the mediating role of the sharing rules in the conceptual framework.

Pooling of responses. The responses from federal and non-federal organizations were pooled in order to maximize statistical power. We assess the viability of this decision via a series of LR tests in a two-group estimation procedure. The structural model is estimated across the federal and non-federal groups, with the hypothesized structural effects (γ_{11}–γ_{27} and β_{31}–β_{52}) constrained to be equivalent across the two groups. The chi-square for this model is 2021.9 (1194 df). The model is then re-estimated, freeing one parameter at a time and an LR test is used to assess parameter equality across the two groups. The only parameter estimate that demonstrates a significant difference across the two groups is the effect of equity sharing on willingness to collaborate in the future (β_{51}). This parameter is nonsignificant (β_{51}=.11, ns) for federal respondents, but significant and positive (β_{51}=.43, $p<.01$) for non-federal respondents.

Parameter estimates. In light of the foregoing structural considerations, we now turn to an examination of the hypothesized parameter estimates in the hypothesized structural model.

Figure 3 and Table 4 displays the completely standardized parameter estimates. The effect of asymmetric inputs (γ_{11}= -.08, ns) on equity sharing is not significant, providing no support for hypothesis 1. Input separability has a significant positive effect (γ_{12}=.26, p<.05) on equity sharing; thus, hypothesis 2 is supported. Jointly idiosyncratic inputs has a nonsignificant effect (γ_{23}= -.10, ns) on equality sharing, providing no support for hypothesis 3. Process interdependence also has a nonsignificant effect (γ_{24}= .01, ns) on equality sharing, providing no support for hypothesis 4. With regard to organizational aspects, the ability to observe the other party's actions has a positive, significant effect (γ_{15}=.23, p<.05) on equity sharing, providing support for hypothesis 5. However, understanding of the transformation process has nonsignificant effects on both equity sharing (γ_{16}= -.14, ns) and equality sharing (γ_{26}= .06, ns). Thus, there is no support for hypothesis 6. Equal payoff valuations has a strong, positive effect (γ_{27}=.48, p<.01) on equality sharing, supporting hypothesis 7. Finally, both equity and equality sharing rules have strong, positive effects on relationship outcomes. Specifically, equity sharing is positively associated with satisfaction with the collaboration (β_{31}=.22, p<.01), outcome fairness (β_{41}=.29, p<.01), and willingness to collaborate in the future (β_{51}=.24, p<.01). Equality sharing is also positively associated with satisfaction with the collaboration (β_{32}=.35, p<.01), outcome fairness (β_{42}=.26, p<.01), and willingness to collaborate in the future (β_{52}=.28, p<.01). Thus, there is support for hypothesis 8.

Collectively, the estimation results indicate that of all the input characteristics and organizational aspects considered, the choice of sharing rule is associated with just a few key factors. Equity sharing is facilitated when the inputs to the collaboration are easily distinguishable among the parties or the parties are able to observe each other's actions, efforts, and activities. Equal sharing is facilitated when the parties value the payoffs similarly. Hence,

the data suggests a simpler model than the conceptual model. Specifically, it suggests that when the collaboration process is tractable – it is relatively easy to observe each party or distinguish between their inputs, then a relatively complex sharing rule will be used. However, when the outcomes are similarly valued, a simpler rule for sharing is employed.

FURTHER CONSIDERATIONS

Equality as a simplifying heuristic. It is useful to consider further any additional insights into the sharing phenomenon that may be afforded from the data. For example, the pattern of significance among the coefficients for the facilitating conditions might suggest that the equality rule is a simplifying heuristic that is used when the collaboration context is too complex to facilitate the use of an equity rule. If this were so, one would expect to observe the input, process and monitoring aspects to have a negative association with the equality sharing rule; however, this did not occur. One might also expect that collaborations with high levels of equity sharing would be characterized by more complex conditions than collaborations with high levels of equality sharing. However, when the means of the facilitating conditions for collaborations located in the upper quartile of the equality scale are compared to the facilitating conditions of other collaborations in the upper quartile of the equity scale, no significant differences are observed.[7] *Collectively, the lack of significance in the coefficients and minimal difference in the facilitating conditions do not support the notion of the equality rule as a simplifying heuristic.*

Anticipation of relationship outcomes. The estimated model demonstrates independent main effect relationships between the facilitating conditions (separable inputs, observability of the other party, and equal payoff valuations) and the sharing rules and between the sharing rules and relational outcomes (satisfaction with the collaboration, outcome fairness, and willingness to

[7] We also examined the means of the facilitating conditions above the equality median and also observed nonsignificant differences with similar conditions among other collaborations above the equity median.

collaborate in the future). It does not consider the possibility that collaboration participants may strategically use the rules *in conjunction* with specific facilitating conditions as a means of insuring *critical relationship outcomes.* Because of the high level of uncertainty in these collaborations, as well as the inability to characterize this uncertainty and the shortage of available partners, there may be some concern that regardless of the ultimate outcome, the participants should feel that collaboration is at least worthwhile, fair in its outcomes, and an endeavor that they may be willing to consider again in the future. This can be further assured by the judicious application of the rules in the presence of specific facilitating conditions; in other words, the facilitating conditions may provide a context wherein a sharing rule may be particularly valuable. Essentially, this speaks to the *appropriateness* of the use of a rule to the collaboration context. Thus, when an equity rule is used and inputs are more easily separated or the ease of observing the other party increases, the combination of the two factors may have a positive effect on critical relationship outcomes. Similarly, when an equality rule is used when the parties value the payoffs similarly, we may observe positive effects on satisfaction, outcome fairness, and willingness to collaborate in the future. These possibilities are examined by estimating the following structural form:

$$\begin{aligned} \text{SATISFAC} = {} & \beta_0 + \beta_1\text{EQUITY} + \beta_2\text{EQUALITY} + \beta_3\text{EQUITY*SEPARATE} + \\ & \beta_4\text{EQUITY*OBSERVE} + \beta_5\text{EQUITY*EQVALUE} + \\ & \beta_6\text{EQUALITY*SEPARATE} + \beta_7\text{EQUALITY*OBSERVE} + \\ & \beta_8\text{EQUALITY*EQVALUE} + \varepsilon_1 \end{aligned}$$

$$\begin{aligned} \text{FAIROUT} = {} & \beta_0 + \beta_1\text{EQUITY} + \beta_2\text{EQUALITY} + \beta_3\text{EQUITY*SEPARATE} + \\ & \beta_4\text{EQUITY*OBSERVE} + \beta_5\text{EQUITY*EQVALUE} + \\ & \beta_6\text{EQUALITY*SEPARATE} + \beta_7\text{EQUALITY*OBSERVE} + \\ & \beta_8\text{EQUALITY*EQVALUE} + \varepsilon_2 \end{aligned}$$

$$\begin{aligned} \text{FUTCOLLB} = {} & \beta_0 + \beta_1\text{EQUITY} + \beta_2\text{EQUALITY} + \beta_3\text{EQUITY*SEPARATE} + \\ & \beta_4\text{EQUITY*OBSERVE} + \beta_5\text{EQUITY*EQVALUE} + \\ & \beta_6\text{EQUALITY*SEPARATE} + \beta_7\text{EQUALITY*OBSERVE} + \\ & \beta_8\text{EQUALITY*EQVALUE} + \varepsilon_3 \end{aligned}$$

SATISFAC, FAIROUT and FUTCOLLB are the dependent variables of satisfaction with the collaboration, outcome fairness, and willingness to collaborate in the future. EQUITY refers to the use of the equity rule, while EQUALITY refers to the use of the equality rule. Consistent with the conceptual model, EQUITY and EQUALITY are represented as having main effects on the dependent variables, while input and organizational aspects are depicted as moderating factors. Both rules are then interacted with the three facilitating conditions that demonstrated a significant main effect: SEPARATE refers to separable inputs, OBSERVE is the ability to observe the other party's actions, and EQVALUE represents equal payoff valuations. This specification allows for the possibility that the use of a rule in conjunction with the facilitating condition for another rule may be inappropriate (e.g., using an equality rule when the inputs are separable or it is relatively easy to observe the other party). β_0 in each equation represents the intercept term, while β_{1-8} represents the coefficients for each effect. ε is the error term for each equation. Because of the difficulty of incorporating numerous interactions in LISREL, the system of equations is estimated using seemingly unrelated regression. The results are displayed in Table 5.

The interactions among the rules and input and organizational aspects are informative. When an equity rule is used and the inputs are separable, there is a marginally significant interaction effect (β_3=.08, p<.10) on outcome fairness. When an equity rule is used and it is relatively easy to observe the other party's actions, there are significant positive interaction effects on satisfaction with the collaboration (β_4=.10, p<.01), outcome fairness (β_4=.05, p<.05), and willingness to collaborate in the future (β_4=.08, p<.01). However, when an equity rule is used and the parties value the outcomes similarly, there are no significant incremental effects on any of the three relationship outcomes. Collectively, it appears that *the use of an equity rule*

when the parties are able to observe each other's actions has significant incremental effects on satisfaction, fairness, and future willingness to collaborate.

When an equality rule is used with separable inputs, there are no significant effects on the relational outcomes of interest. However, there is a marginally significant negative effect on satisfaction with the collaboration if an equality rule is used when an organization is able to observe the other party's actions, efforts, and activities. This suggests that the use of an equality rule when the other party's actions are observable may have a detrimental effect on satisfaction with the collaboration. When an equality rule is used and the parties value the outcomes similarly, there is a significant incremental effect on outcome fairness (β_8=.10, p<.01) and a marginally significant interaction effect on willingness to collaborate in the future (β_8=.07, p<.10). *This suggests that the use of an equality rule when both parties have equal payoff valuations facilitates perceptions of outcome fairness.* Collectively, the results provide further insights into the use of sharing rules, beyond the conceptual model of figure 1.

DISCUSSION

This research has examined how input, task, and organizational aspects of collaborations in noisy environments impact the choice of sharing rules and their consequential effects on key relationship outcomes. The results indicate that the use of an equity rule in noisy collaborations is facilitated when the inputs to a collaboration are separable and it is possible to observe the other party's actions. On the other hand, equality sharing rules are facilitated when the parties value the payoffs similarly. Both rules promote desirable relationship outcomes such as satisfaction with the collaboration, outcome fairness, and willingness to collaborate in the future. These results are consistent for both federal and non-federal organizations, with the exception of the effect of an equity rule on willingness to collaborate in the future. Evidently, the ability to gain back the value of its inputs is less of a concern among federal organizations in determining

whether to collaborate again with a firm; however, this concern is important for nonfederal organizations.

Further consideration of the conceptual model and data provide some surprising insights. First, it appears that an equality rule is not necessarily used as a simplifying heuristic in these complex collaborations. Both rules are used under equally complex conditions. Second, there are several insights regarding the effectiveness of each rule in conjunction with specific facilitating conditions as a means of critical relationship outcomes. The use of an equity rule is particularly effective at enhancing collaboration satisfaction, outcome fairness and willingness to engage in future collaborations if it is relatively easy for each party to observe the other party's actions. The use of an equality rule when both parties value the outcomes similarly is also useful for facilitating each party's sense of fairness regarding its outcome from the collaboration. Hence, it appears that the relational impact of the sharing rules are contingent on a relatively high level of input separability, other party observability, or similarly valued payoffs.

It was surprising that asymmetric and jointly idiosyncratic inputs did not have a significant effect on sharing rules. This may be because the criticality of these inputs is more important than their sheer quantities. For example, one organization may contribute equipment, research facilities, and related test results to a collaboration while the other party contributes only a patented process. Although the latter organization contributes much less in terms of sheer quantity, the importance of its contribution enables it to account for a much larger share of the pie, perhaps even as much as 50%. The inputs and equity scales appear to track quantities of inputs without taking into account the criticality of the inputs in determining the outputs. In this example, the quantity of inputs would have no effect on a rule that allocates outcomes according to the quantity of the input.

We also note that interdependence of the task between the parties had little effect on the use of equity or equality sharing rules. It may be that interdependence is so pervasive among these type of collaborations that it does not have a unique effect on the sharing rules. When we examine the distribution of responses to the process interdependence scale, we note that the median is at 5, and that upper quartile of the distribution is located between 5.75 and 7, compared to the lowest quartile, located between 4 and 1. Thus, there appears to be a more concentrated cluster of respondents in the upper quartile, which would suggest a high level of interdependence in the referent collaborations.

Understanding of the transformation process played a minimal role in facilitating the use of sharing rules. It may be that this construct was too broadly construed to capture this effect. There may be various levels of understanding ranging from a broad holistic level of how the process transforms inputs to outputs to a very intimate understanding of details of the process. While we doubt that many collaborations were marked by the latter level of understanding (it diminishes the need to collaborate with an outside organization), each extreme may have different effects on sharing that were not captured in this research.

However, the results do shed insight into several aspects regarding the use of fundamental sharing rules in complex environments. At one level, we observe the value of these rules in noisy collaborations. Participants will try to safeguard their investments and interests by using the rules (i) when the inputs are separable among them or (ii) it is relatively easy to observe each other or (iii) both parties value the payoffs similarly. The use of these rules facilitate key relationship outcomes such as satisfaction with the collaboration, outcome fairness and willingness to collaborate again in the future. Moreover, the results indicate that the participants in these collaborations also use the rules in conjunction with these input and organizational aspects as a means by which to insure critical relational outcomes. Hence, *we see*

that participants in noisy collaborations not only use these rules to strategically safeguard their investments and interests but to also provide for important relational aspects. This is consistent with the nature of the marketplace, in which the pool of potential partners is small and there is an emphasis on repeated collaborations with the same partners over time.

LIMITATIONS

There are a few limitations to consider with regard to the results. First, our survey methodology may have created common method variance that could have inflated construct relationships. This could be particularly threatening if the survey respondents were providing us with responses that they felt were socially acceptable -- i.e., positive relationship outcomes and a high degree of sharing. However, the respondents were never told that sharing was the specific issues of interest in this study, nor did anyone in our pretest efforts guess that this was the real purpose of the study. Respondents were merely told that the purpose of the study was to understand how to better manage R&D collaborations between organizations. Additionally, the items for all of the constructs were separated and mixed with items of other constructs so that no one respondent would be able to detect which items were affecting which factors. Hence, we feel that the biasing possibilities of common method variance were minimized to some degree.

Clearly, there are many other factors that could affect the use of sharing rules and the type of rules that are used in noisy collaboration environments. This study does not attempt or claim to consider all of the possible facilitating conditions that exist in sharing the outcomes of collaborations, nor does it attempt to provide a listing of all the rules that exist. Instead, this research is an attempt to study a subset of the possible facilitating conditions and strategies that comprise interorganizational sharing. To this end, this research represents an incremental, *first step* toward better understanding this rich interorganizational phenomenon.

DIRECTIONS FOR FUTURE RESEARCH

There remains many aspects of interorganizational sharing yet to be understood. For example, one aspect that was not explicitly investigated in this research is the effect of the external environment on sharing strategies. In particular, one interesting aspect to consider would be the interaction of a technology lifecycle and the nature of sharing in interorganizational collaborations. Canairca, Colombo & Mariotti (1992) have examined how types of agreements in equity ventures should vary appropriately at various stages of a technology lifecycle. *It is possible that sharing strategies might also vary systematically over the lifecycle.* It may be that equity rules are appropriate in the early stages of the lifecycle when it is easy to distinguish the inputs and efforts of both organizations, but over time, the organizations realize they value the outcomes similarly and equality rules become a more effective way to share the pie.

The issue of fairness and how it is determined in noisy environments is also worth examining further. Although work has been done on fairness perceptions in asymmetric power relationships (i.e., Kumar, Scheer & Steenkamp 1995), *there is little that has examined fairness in noisy collaborations between symmetrically powerful organizations.* In particular, one aspect that has not been considered to date is how perceptual biases affect fairness perceptions. Work in psychology indicates that participants in tasks requiring joint efforts tend to overestimate the inputs that they contribute toward a task and underestimate the outputs received with detrimental effects on outcomes (i.e., Messick & Sentis 1985; Thompson & Loewenstein 1992). *These biases might be operative at an interorganizational level*, where they could have a critical effect on perceptions of interorganizational fairness.

Finally, although we have examined the impact of various sharing rules on relationship outcomes, future research might investigate *the impact of these rules on interorganizational behavior and processes.* It may be that the choice of a sharing rule impacts how organizations

work together – e.g., does the use of an equality rule cause the parties to be less productive in their individual efforts? Such possibilities are worth investigating in future research.

In this research, we have tried to discover the rules that are used in practice to deal with interorganizational collaborations in 'noisy environments.' Our results indicate that simplicity is critical in such an environment – the choice of rules and their consequential impact on relationship outcomes is driven by key aspects of the input characteristics and organizational aspects. By observing the rules and conditions under which the rules are used, we are able to infer something about the information environment in which these rules exist. We might also have stimulated thinking on how to better design the rules.

FIGURE 1
CONCEPTUAL FRAMEWORK

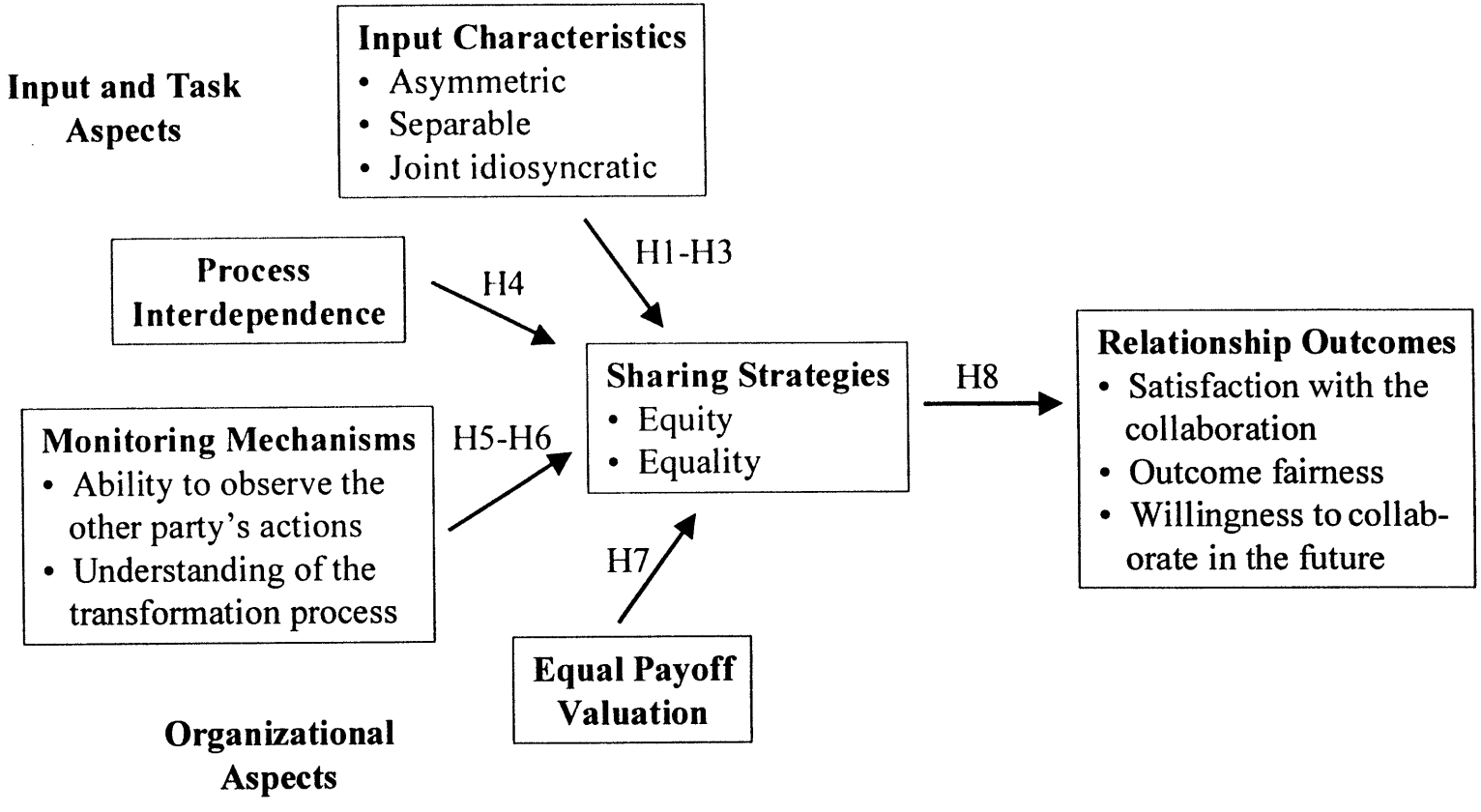
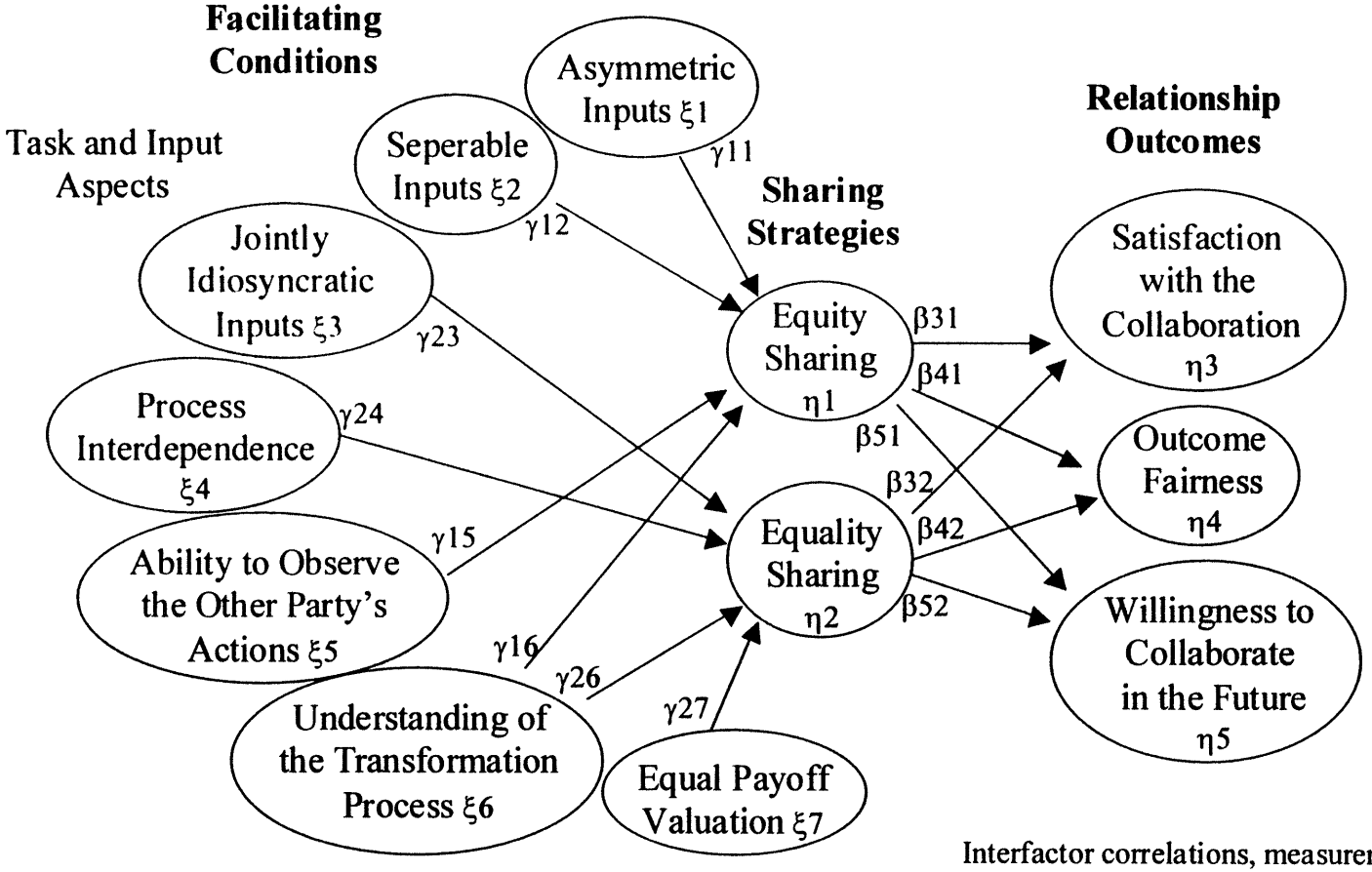
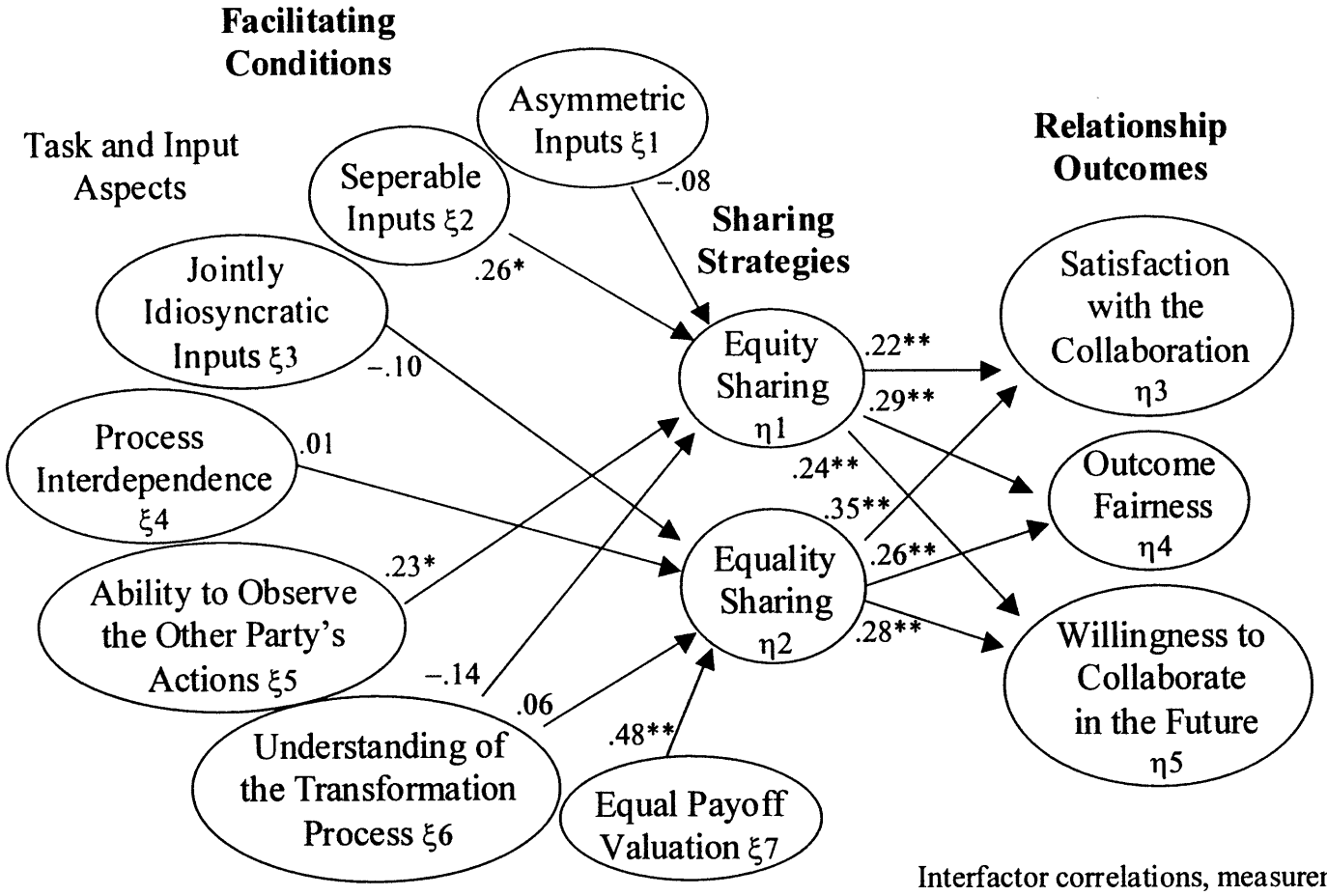


FIGURE 2
STRUCTURAL MODEL



Interfactor correlations, measurement errors, and latent variable errors are not depicted for ease of presentation.

FIGURE 3
ESTIMATED STRUCTURAL MODEL



Interfactor correlations, measurement errors, and latent variable errors are not depicted for ease of presentation.

* α=.05, ** α=.01

TABLE 1
INPUTS TO R&D COLLABORATIONS

Inputs Contributed	Our Contribution	Their Contribution
Specific expertise	85%	81%
Human resources	86	78
Intellectual property	75	65
Engineering skills	69	62
Management skills	66	53
Data	68	56
Software	44	40
Equipment	58	62
Components	44	40
Funding	62	56

Our contribution indicates the proportion of respondents that checkmarked the specified input as a contribution of their organization. **Their contribution** indicates the proportion of respondents that checkmarked the specified input as a contribution of the other organization.

n=299

TABLE 2
R&D COLLABORATION BENEFITS

Collaboration Benefits	Our Benefits Gained	Their Benefits Gained
Understanding or knowledge	80%	76%
Reputation enhancement	60	51
Application of technology	64	52
Leveraging of other party's resources	60	55
Test Results (includes field tests)	70	68
Solidify relationship with other party	60	56
Exposure to future technology developments	50	50
Creation of future R&D options	54	47
Intellectual property	45	44
Potential commercial applications	42	44
Access to the other party's previous research	48	52
Components or parts	27	24
Planning advantages	29	25
Control over future technologies	33	31
Reduced time to market	24	20
Patents	14	14
Exclusivities	14	12
Royalties	10	10

Our benefits gained indicates the proportion of respondents that checkmarked the specified benefit as an outcome that their organization gained from the collaboration.
Their benefits gained indicates the proportion of respondents that checkmarked the specified benefit as an outcome that the other organization gained from the collaboration.

n=299

TABLE 3

MEANS, STANDARD DEVIATIONS AND CORRELATIONS

	Variable	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12
1.	Equity Sharing	4.30	1.2	1	7	----											
2.	Equality Sharing	4.19	1.2	1	7	**0.08**	----										
3.	Asymmetric Inputs	3.46	1.6	1	7	**-0.10**	-0.18	----									
4.	Separable Inputs	5.41	1.1	2	7	0.15	0.14	**-0.10**	----								
5.	Joint Idiosyncratic Inputs	4.58	1.3	1	7	0.19	0.19	-0.20	0.12	----							
6.	Process Interdependence	4.90	1.2	1	7	0.17	0.12	-0.12	**0.10**	0.39	----						
7.	Ability to Observe the Other Party's Actions	4.10	1.6	1	7	0.17	0.23	-0.19	0.13	0.15	0.25	----					
8.	Understanding of the Transformation Process	5.52	1.1	1.7	7	**0.03**	0.18	**-0.10**	0.47	0.24	0.33	0.24	----				
9.	Equal Payoff Valuation	4.91	1.4	1	7	0.18	0.36	-0.23	0.25	0.50	0.28	0.26	0.29	----			
10.	Satisfaction with the Collaboration	5.06	1.3	1	7	0.19	0.30	-0.27	0.21	0.45	0.26	0.29	0.17	0.43	----		
11.	Outcome Fairness	5.40	1.0	1	7	0.22	0.25	-0.28	0.33	0.42	0.33	0.29	0.29	0.48	0.75	----	
12.	Willingness to Collaborate in the Future	5.82	1.3	1	7	0.21	0.26	-0.23	0.30	0.44	0.24	0.28	0.20	0.44	0.73	0.76	----

Correlations in bold are **not** significant at $\alpha = .05$

TABLE 4
STRUCTURAL MODEL ESTIMATES

Effect	Estimate
Asymmetric Inputs -> Equity Sharing (γ_{11})	-.08
Separable Inputs -> Equity Sharing (γ_{12})	.26*
Jointly Idiosyncratic Inputs -> Equality Sharing (γ_{23})	-.10
Process Interdependence -> Equality Sharing (γ_{24})	.01
Ability to Observe the Other Party's Actions -> Equity Sharing (γ_{15})	.23*
Understanding of the Transformation Process -> Equity Sharing (γ_{16})	-.14
Understanding of the Transformation Process -> Equality Sharing (γ_{26})	.06
Equal Payoff Valuation -> Equality Sharing (γ_{27})	.48**
Equity Sharing -> Satisfaction with the Collaboration (β_{31})	.22**
Equity Sharing -> Outcome Fairness (β_{41})	.29**
Equity Sharing -> Willingness to Collaborate in the Future (β_{51})	.24**
Equality Sharing -> Satisfaction with the Collaboration (β_{32})	.35**
Equality Sharing ->Outcome Fairness (β_{42})	.26**
Equality Sharing -> Willingness to Collaborate in the Future (β_{52})	.28**

* α=.05, ** α=.01

Estimates are completely standardized.

TABLE 5

SUR ESTIMATION RESULTS

Independent Variable	Satisfaction with the collaboration	Outcome Fairness	Willingness to collaborate in the future
β_0	3.68***	3.88***	4.69***
EQUITY	-.17	-.30*	-.32
EQUALITY	-.24	-.22	-.26
EQUITY*SEPARATE	-.07	.08*	.01
EQUITY*OBSERVE	.10***	.05**	.08***
EQUITY*EQVALUE	.04	-.02	.03
EQUALITY*SEPARATE	.10	-.02	.07
EQUALITY*OBSERVE	-.06*	-.02	-.05
EQUALITY*EQVALUE	.05	.10***	.07*

* $\alpha = .10$, ** $\alpha = .05$, *** $\alpha = .01$

EQUITY = use of the equity rule

EQUALITY = use of the equality rule

SEPARATE = separable inputs

OBSERVE = the ability to observe the other party's actions

EQVALUE = equal payoff valuations

APPENDIX

ITEMS, RELIABILITIES, LOADINGS AND MEASUREMENT ERRORS

Asymmetric Inputs (α = .87)	Loading	Meas Error
Our organization has made greater contributions to complete the task than the other party.	0.83	0.31
Our inputs to the R&D effort were greater than the other organization's inputs.	0.85	0.27
We have contributed more resources to this effort than the other party.	0.79	0.37

Separable Inputs (α = .64)	Loading	Meas Error
It is difficult to trace each party's contributions to the task.	0.48	0.77
Each party's inputs into the task are easily separated.	0.71	0.49
Each party's contributions to the task are distinct.	0.66	0.56

Jointly Idiosyncratic Inputs (α = .76)	Loading	Meas Error
Both organizations have made investments that would be lost if the relationship were prematurely terminated.	0.78	0.39
If the collaboration were to end, both organizations would waste a lot of knowledge that's tailored to their relationship.	0.76	0.42
Both organizations have made investments that are unique to this relationship.	0.54	0.71
If either organization were to switch to another partner, they would lose a lot of the investments made in the present relationship.	0.58	0.66

Process Interdependence (α = .79)	Loading	Meas Error
The various aspects of the task are extremely interconnected.	0.67	0.54
Each party's role in the task was extremely interconnected.	0.83	0.31
Each party's activities were highly dependent on the other's activities.	0.69	0.53
The process of completing the task required the mutual effort of both parties.	0.57	0.67

Ability to Observe the Other Party's Actions (α = .88)	Loading	Meas Error
We can easily observe their actions.	0.95	0.10
It is easy for us to observe their efforts.	0.92	0.16
It is difficult for us to observe their activities.	0.68	0.54

Understanding of the Transformation Process (α = .78)	Loading	Meas Error
We know the processes and actions that the other party must do in this task.	0.66	0.56
We understand well what the role of the other organization is in completing this task.	0.82	0.32
We can comprehend what the other party must do to accomplish their share of the task.	0.73	0.47

Equal Payoff Valuation	Loading	Meas Error
Both parties value the payoffs of this relationship similarly.	0.82	0.32
The benefits of this collaboration are equally valued by both organizations.	0.82	0.33

Equity Sharing (α = .77)	Loading	Meas Error
An organization's inputs to the collaboration determine its share of the outputs of working together.	0.69	0.52
Each organization's share of the benefits of this collaboration depends on its contributions to the task.	0.76	0.42
Each organization's share of the outcomes depends on what it provides to support the joint effort.	0.72	0.48

Equality Sharing (α = .78)	Loading	Meas Error
The organizations share the outcomes of the collaboration equally between them.	0.56	0.68
Each party receives half of all benefits from the collaboration.	0.76	0.42
The gains from the joint effort are equally shared between the organizations.	0.90	0.19

Outcome Fairness (α = .86)	Loading	Meas Error
Our outcomes received from this collaboration are just.	0.75	0.43
The benefits of collaboration with them have been fair.	0.82	0.33
Our gains from this collaboration have been fair.	0.85	0.27

Satisfaction with the Collaboration (α = .90)	Loading	Meas Error
Our collaboration with them has been a successful one.	0.87	0.24
Our collaboration with them has more than fulfilled our expectations.	0.82	0.33
We are satisfied with the outcomes from this collaboration.	0.93	0.14

Willingness to Collaborate in the Future (α = .94)	Loading	Meas Error
We would welcome the possibility of additional collaboration in the future.	0.88	0.22
We would be willing to work with them again in the future.	0.94	0.11
We would be willing to collaborate with them again, should the opportunity arise.	0.94	0.12

ADDITIONAL MEASURES FOR VALIDITY CHECKS

Types of R&D Collaborations

R&D Collaborations differ in many ways. Which of the following best describe the nature of the collaboration between you and this organization? *(select only one)*

Frequency (% of sample)	
25 (8.4%)	*Tier 0:* Basic research that lays the foundations for additional R&D.
29 (9.8%)	*Tier 1:* Long-term explorations in science and/or technology to build or maintain basic capabilities. The use of basic foundations to explore tools of the future.
71 (24.1%)	*Tier 2:* Directed programs of activities to develop practical competencies that support or fulfill an organization's strategic directions. The creation of tools.
135 (45.8%)	*Tier 3:* Applied projects aimed at specific tasks with clearly defined, more immediate goals. Pioneering the use of created tools.
39 (13.2%)	*Tier 4:* Routine engineering for continuous improvement of products and processes. Routine use of the tools.

As an example, consider an organization that wants to communicate detailed 3- dimensional (3D) images to and from a remote field site. Tier 0 might be the development of the fractal mathematics that allow the images to be coded for transmission; tier 1 might include the development of algorithms that use fractal mathematics to code the images; tier 2 researchers might write the software and develop (or buy) the hardware to implement the algorithms; tier 3 research may involve the development of a pilot application to demonstrate the 3D imaging system and solve problems of implementation. Tier 4 might involve handing the 3D imaging system to the business units.

Environmental Dynamism	Loading	Meas Error
Technology practices in our industry are constantly changing.	0.81	0.57
The standards for competition in our industry are constantly shifting.	0.61	0.79

Norms-Flexibility (α = .84)	Loading	Meas Error
The parties are willing to make adjustments when circumstances change.	0.73	0.46
The organizations are flexible in responding to requests for changes.	0.84	0.29
When an unexpected situation arises, the parties adapt easily.	0.83	0.30

Norms-Solidarity (α = .63)	Loading	Meas Error
Both parties are concerned about their shared welfare, not just individual gains.	0.53	0.72
Both organizations are open to improvements that may benefit the collaboration as a whole, not only the individual parties.	0.67	0.55
Problems that arise are treated by the organizations as joint rather than individual responsibilities.	0.62	0.62

Norms-Participation (α = .70)	Loading	Meas Error
The organizations consult each other when setting goals.	0.77	0.41
The organizations play an active role in various decisions regarding the collaboration.	0.61	0.63
Both parties seek and consider the other's opinions and suggestions regarding how to accomplish various tasks.	0.61	0.63

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