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COMMUNICATION AND MOTIVATIONAL PREDICTORS OF THE DYNAMICS OF ORGANIZATIONAL INNOVATION*

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This paper reports on research designed to test a dynamic model of the causes of organizational innovation. Two communication variables (level of information and group communication) and three motivational variables (perceptions of equity, expectations of benefits, and perceived social pressure) were derived from equity theory, expectancy theory and the theory of reasoned action. These variables were used to predict the number of innovative ideas contributed by members of the organizations. Weekly data were collected for over a year from five firms and were analyzed with multivariate time series techniques. The results indicated that the communication variables were causes of organizational innovation but the motivational variables were not. Across the five firms, the variance explained by the model ranged from a low of 30 percent to a high of 78 percent. In four of the five firms, the forecast accuracy for the amount of individual innovation ranged from a low of 77 percent to a high of 85 percent.
(ORGANIZATIONAL INNOVATION; LEVEL OF INFORMATION; GROUP COMMUNICATION)

Communication and Motivational Predictors of the Dynamics of Organizational Innovation

The innovation process has attracted the attention of organizational theorists over many decades (Aiken and Hage 1971, Barnard 1938, Burns and Stalker 1961, Kanter 1983, March and Simon 1958, Rogers and Shoemaker 1971, Rogers 1983, Van de Ven 1986). Recently, however, innovativeness has become an important organizational strategy, and many organizations have tried to facilitate innovation. As global competition has increased, organizations have been forced to cut costs and improve efficiency in order to survive. An assumption affecting this trend is that organizations which generate and implement more good ideas about better, more efficient ways of working have a distinct advantage in a competitive environment.

Organizational Efforts to Increase Innovation

Participative management procedures is one way some organizations have involved employees in the process of improving organizational performance. Often this occurs through formal and informal solicitations of ideas about how things might be done more effectively. One simple approach involves the creation of a formal system for gathering possible innovations proposed by organization members (Monge and Cozzens 1986). In addition, organizations may try to cultivate a climate of innovativeness (Amabile 1988, Kanter 1988a, Morton 1971). Organizations may also facilitate innovation through project teams or R & D departments (Morton 1971, Zaltman, Duncan, and Holbek 1973). Finally, organizations may actively search their environ-

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ments for innovative methods or products in order to insure success (Kanter 1988a, Mohr 1969, Tushman 1977).

This research considers two critical processes which lead to the creation and subsequent implementation of innovations in organizations. First, individual level motivational processes are discussed, and corresponding hypotheses are derived from several micro level organizational theories. Second, the role of information and communication is discussed. Hypotheses concerning the importance of information in the innovation process are also proposed. Both processes are tested with a dynamic model and longitudinal data.

Individual Motivation and the Innovation Process

The effectiveness of any system for generating innovations depends on many things, one of which is the individuals who find, invent, or propose useful innovations. In a formal organizational setting, intentional innovation requires motivated individuals. Organizational members must be willing to contribute time and effort to the development of innovative ideas. Some organizational positions, such as those in R & D groups, are defined such that individuals in these positions are expected to develop innovations. In these cases, the individuals are presumably motivated by the various rewards and punishments associated with an employee's expected performance; for example, job security, wages, promotions, etc.

In an organization where innovation is merely encouraged throughout all departments, the rewards and punishments are less directly tied to each individual's performance. For example, in a company-wide suggestion system where involvement or participation is encouraged but not required, individual suggestions may lead to increases in organizational productivity, which lead to a financially stronger organization, which may ultimately enhance the job security of all employees. In such cases, the rewards and punishments associated with involvement in innovation are much more indirect. Consequences of innovation for individuals may be direct or indirect; however, the same theories of organizational behavior may be used to derive hypotheses related to individuals' involvement in the generation of innovations.

Expectancy and Innovation. Expectancy models have been used to predict a variety of organizational behaviors, including occupational preference, job effort, job performance, and retirement (see Campbell and Pritchard 1976, Landy and Becker 1987, Mitchell 1973, 1982, for theoretical and empirical reviews of this research). A major conclusion from these studies is that individual beliefs about the consequences of specific actions predict target actions. In the present research, changes over time in beliefs about the consequences (positive and negative) of individual involvement in the process of contributing innovations to the organization are expected to predict the subsequent level of contribution. One major kind of behavioral involvement in an innovation system is contributing innovative ideas that may eventually become fully implemented innovations in the organization. The volitional process whereby individuals become involved in an innovation system suggests the following hypothesis.

H_1. Over time, higher levels of expectancy of benefits from involvement in an innovation system will cause subsequently higher levels of involvement in the innovation system.

Equity and Innovation. Equity theory is an alternative model of motivated behavior in organizations. Individual participation in a system of innovation may be determined in part by equity processes. For example, Frost, Wakeley, and Ruh (1974) propose that the motivation for employees to be involved in the innovation process is dependent upon "equitably rewarding all members of the organization" (p. 1). Adams (1965) had posited that perceptions of inequity are accompanied by tension. It is this tension, Adams (1965) argues, that provides the motivation to reduce perceived inequity. In the organizational context, the magnitude and direction of the motivation to reduce perceived inequity is manifested in terms of motivational outcomes.

For example, employees have expectations about what they should receive in return for their contributions to the organization. When employees perceive a discrepancy between what they believe they should receive compared to what they actually receive, inequity is said to exist. The tension resulting from this inequity provides employees with the motivation to act in ways that will reduce the perceived inequity (Goodman and Friedman 1971, Greenberg 1982). Reducing their level of involvement in organizational processes such as the innovation system provides employees with a rationale to reduce their expectations of what they should receive. When compared to what employees actually receive, the reduced expectation will reduce the perceived inequity. Hence, the mechanism of equity theory predicts that employees with higher levels of perceived inequity because of underreward are less likely to be involved in the innovation system than those with lower levels of perceived inequity. Conversely, perceived inequity caused by overreward may be reduced through greater involvement in the innovation system (Contractor 1988, Goodman and Friedman 1971, Greenberg 1982, Landy and Becker 1987, Mowday 1983, Pritchard 1969). The following hypothesis represents this reasoning.

H_2. Over time, higher levels of perceived underreward inequity will cause subsequently lower levels of involvement in the innovation system; likewise, higher levels of perceived overreward inequity will subsequently cause higher levels of involvement in the innovation system.

Social Pressure and Innovation. Fishbein and Ajzen developed a motivational model of social behavior that includes the concept of *social normative pressure* with an expectancy component (see Ajzen and Fishbein 1980, Fishbein 1967, Fishbein and Ajzen 1975, Graen 1969). Fishbein and Ajzen defined this construct, social normative pressure, as the degree to which individuals (1) perceive social pressure or expectations to engage in some behavior and (2) feel motivated to comply with that pressure. Fishbein and Ajzen further proposed one means of operationalizing the construct, namely as the sum of the products of a normative belief term and a corresponding motivation to comply term. However, Fishbein and Ajzen have also admitted that this means of operationalization may not be the best possible (see Ajzen and Fishbein 1980, p. 246). The conceptual definition refers to both the perceptions of social pressure to behave in certain ways and the individual's desire to comply with that pressure. An alternative method of representing the role of social pressure in predicting behavior is to incorporate the role of social pressure into an expectancy model with desired social relations representing one possible outcome of the behavior (see, for example, the discussion by Campbell and Pritchard 1976).

Several empirical studies have appeared in the organizational literature which either used or adapted Fishbein and Ajzen's "theory of reasoned action" to predict individual organizational behaviors. This elaborated expectancy model has been shown to predict faculty members' effort in activities such as administrative work, service tasks, and clinical preparation (Mitchell and Pollard 1973), the number of hours students devoted to academic activities (Mitchell and Nebeker 1973), occupational choice (Mitchell and Knudsen 1973), and employees' general involvement in organizational activities (Cozzens 1988). This latter study showed that while the expectancy component was positively related to involvement, perceived social pressure was the major predictor, accounting for over 50% of the variance in the dependent measure (Cozzens 1988). These empirical findings illustrate the importance of considering social pressure in the prediction of some kinds of organizational behaviors and suggest the following hypothesis regarding involvement in the generation of innovations in organizations.

H_3. Over time, higher levels of perceived social pressure to be involved in the innovation system will cause subsequently higher levels of involvement in the innovation system.

Communication and Innovation

Several empirical studies have shown that higher levels of communication and information gathering are associated with higher levels of performance in R & D project groups (Katz 1982, Keller 1986, Keller and Holland 1983, Pelz and Andrews 1966) and organizational innovation in general (Aiken and Hage 1971, Evan and Black 1967, Kanter 1982, 1988a, Tjosvold and McNeely 1988). These kinds of findings are explained in part by Van de Ven (1986) who argues that as individuals have access to more information about available innovations and are more globally informed about the implications of innovative ideas, they are better able to relate the "parts to the whole." In general, individuals with a broader awareness of the consequences and implications of innovative ideas facilitate the process of organizational innovation.

Aiken, Bacharach and French (1980) and Katz and Tushman (1979) found that the patterns of communication and information flows in innovative organizations or groups were dependent on the information needs of the unit and were related to successful innovation. For example, given very complex problems to solve, the more effective innovation was associated with widespread face to face communication between members in the research group as well as with others outside of the group. In contrast, given less complex problems, effective innovation was associated with the presence of a few key boundary spanning communication links (Katz and Tushman 1979). In both cases access to relevant information sources was important; however, the patterns of access provided by communication links were critical.

Tjosvold (1985) and Tjosvold and McNeely (1988) illustrate the dynamics of information sharing in interpersonal communication in both laboratory (1985) and field settings (1988). In the experimental study of small group discussions, Tjosvold (1985) compared the effect of cooperative versus competitive group conditions. As hypothesized, cooperative group contexts resulted in greater exchange of information and ideas and led to higher quality solutions for a hypothetical organizational problem. Tjosvold and McNeely (1988) confirmed the experimental results in a field setting. They studied innovation in an educational bureaucracy through a series of personal interviews. Results showed that only under conditions of cooperation was there effective information sharing that positively affected the quality of innovation.

Kanter (1982) reported a field study of 165 "effective" middle level managers in five different companies. The analysis of personal interview data from each of the 165 managers showed that: (1) the greater the flow of information across organization units, the greater the innovation; and (2) the greater the managerial overlap of territory and contact across functions in the organization, the greater the innovation. Implicit in the second finding is that given greater overlap of territory and contact, there is greater knowledge about the implications and consequences of possible innovations. Kanter also found that the most innovative managers practice a participative management style in which information is sought from subordinates. Kanter's (1983, 1988b) continuing research, including studies of organizational contexts that facilitate effective innovation, demonstrates the critical role of communication and information exchange.

Communication in general may facilitate innovation in organizations. In a study of the communication networks in three organizations, Albrecht and Ropp (1984)

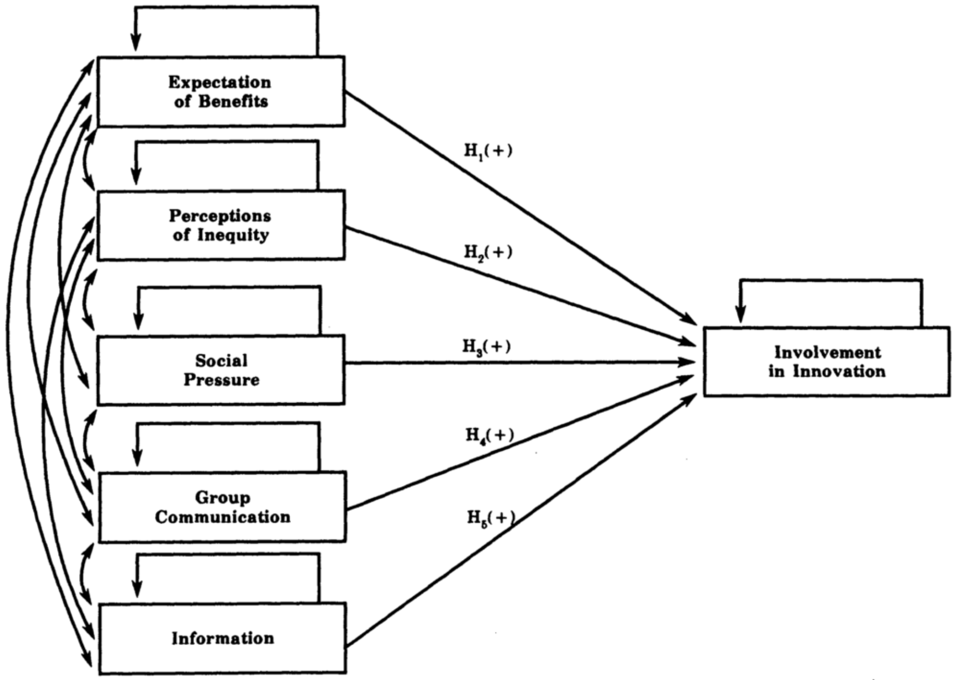

FIGURE 1. Theoretical Model of Motivational and Communication Factors That Predict Innovation. The feedback arrows on the top of each box represent the influence of the variable's autoregressive and moving average history on itself.

reported that communication about innovations was much more frequent between individuals who discuss work and social/personal topics in addition to innovations. According to these researchers, their findings suggest that "discussion of innovation in organizations is facilitated by the occurrence of other types of personal communication" (p. 87). Most discussions of innovations occur in the general context of high multiplexity of communication links. This finding and conclusion is consistent with the empirical research cited above and leads to hypotheses H_4 and H_5 below.

H_4. Over time, higher levels of group communication will cause subsequently higher levels of employee involvement in the innovation system.

H_5. Over time, higher levels of information about the organization will cause subsequently higher levels of employee involvement in the innovation system.

The theories and research discussed above suggest that both individual motivational processes and communication effect innovation. A model which integrates hypotheses H_1 to H_5 is presented diagrammatically in Figure 1.

The Scanlon System and Organizational Innovations

An adequate test of this model requires organizations which operate under a management philosophy designed to foster innovation among employees by means of the relevant motivational and communication processes described above. The Scanlon system is a form of participative management which focuses on productivity improvement through the generation of innovations to solve organizational problems (Monge and Cozzens 1986). As described below, it does so through a series of psychological and communicative mechanisms designed to increase individual levels of involvement in the organizational innovation system (see Frost, Wakeley and Ruh 1974, Geare 1976, Goodman, Wakeley and Ruh 1972, Lesieur 1958, McGregor 1960, Moore and Ross 1978, Schuster 1983, and White 1979 for reviews of this research).

Innovations. The success of a Scanlon system depends upon the ability of a firm's employees to generate innovations. The people closest to each aspect of the work life are assumed to be best qualified to generate innovative improvements to their work products and processes. Hence, in the Scanlon system the emphasis is on everyone contributing incremental innovations rather than a few people contributing radical innovations (Tornatzky et al. 1983).

The Scanlon system is operated by two structural arrangements, the Scanlon committee and the screening committee. The latter, which is elected by employees, is specifically responsible for the management of the innovation subsystem. It encourages innovations from employees, evaluates them, communicates the results of its assessment, and assigns responsibility for implementation.

That the Scanlon system is effective in generating innovations has been shown by Schuster (1984). This researcher reports that one Scanlon firm employing 890 production workers received over 2,477 suggestions over a five-year period. Much earlier Whyte (1955) reported that Scanlon firms generated and accepted more innovations than non-Scanlon firms. Scanlon firms accepted 80 percent while non-Scanlon firms accepted 25 percent (also see Lawler 1986).

Expectations. The success of the Scanlon system depends in part on the expectations employees have regarding the consequences of their involvement in the various elements of the system. In particular, employees must believe that their involvement will result in personal benefits. Expected benefits in the Scanlon system are monetary in the form of bonuses, equity in the distribution of bonuses, enhanced job security, and good working conditions in organizational relationships. In addition, the opportunity to participate in many aspects of organizational decision making may be viewed as a benefit.

Equity. The Scanlon system is managed as a productivity improvement, profit-sharing system. Equity is the mechanism for sharing the gains which accrue from the innovation subsystem. The gains in profit that are attributable to employee innovations are distributed among all employees proportionally to their wages. Implicit in the Scanlon system is the notion that perceived equity will result from equitable distribution of rewards and will motivate employees to make larger contributions to the innovation system.

Social Pressure. Frost, Wakeley, and Ruh (1974) and Frost (1978) identify four major Scanlon principles: identity, participation, equity, and managerial competence. Social pressure to operate by these principles is a central aspect of the system. In many implementations, the Scanlon system is adopted only after months of collective examination and approval by a 90 percent majority vote of all employees. After the first year of operation it is typical for a second referendum to be taken to determine whether to continue the system. If less than 90 percent approve, it is discontinued. The Scanlon Committee is responsible for developing and maintaining the social pressure to support these norms. It utilizes a variety of mechanisms, such as monthly meetings to influence individual contributions to the innovation system.

Group Communication. Group communication is a central part of the participative process (Monge and Miller 1988). In the Scanlon system group communication is designed to facilitate innovation and problem solving. Work group meetings are held on a regular basis to share information and to solve problems. Individuals are encouraged to propose risky and imaginative solutions before evaluating their likely impacts on the firm. Much of the information that is necessary to develop useful innovations is expressed in these group settings.

Information. The Scanlon system operates on the assumption that well-informed employees are more likely to contribute innovations than those who are poorly informed. Employees at all levels are encouraged to learn as much as possible about the four major constituents of the firm: clients, stockholders, suppliers, and employees. Further, they are challenged to become knowledgeable about the organization's operations, commitments, external challenges and opportunities.

This review of the Scanlon management system indicates that it operates in accordance with the relations specified among the six variables in the model. Hence, it provides an appropriate environment in which to test the model.

Method

Sample

The present test of the predictors of organizational innovation was conducted in five organizations. Data were collected from the employees of five manufacturing companies located in the midwestern and southeastern United States. Each of the organizations operated in accordance with the Scanlon system of participative management. The following is a brief description of the five companies surveyed:

Company A. Company A, which has about 1300 employees, is a major manufacturer of hydraulic systems for the petroleum industry. It produces gauges and fluid systems used in the petroleum industry. It adopted the Scanlon Plan in 1983.

Companies B & D. Companies B and D are two plants of a large metal manufacturing company. They produce and refine magnetic wire. The two plants, located in the southeastern United States, employ approximately 150 employees. The two plants are over 50 years old and adopted the Scanlon Plan in 1982.

Company C. Company C is a family-owned manufacturer of quality hand-crafted furniture. Company C, located in the midwestern United States, has been in existence for over 100 years and adopted the Scanlon Plan in 1972. However, Company C management views the Scanlon Plan primarily as an incentive plan rather than a management philosophy. The company has approximately 230 employees.

Company E. Company E is a 12-year old midwestern company which does short-run printing of academic items for several universities across the nation. It employs approximately 90 people and was recently computerized. Company E adopted the Scanlon Plan in 1980 and achieved a significant profit increase in the following year. Since then profits have remained steady. Company E is typically involved in price rather than quality competition.

Procedures

Data were collected as part of a larger longitudinal research program investigating a variety of organizational and communication processes including motivation, involvement, equity, reward, innovation, climate formation and influence, social information processing, and organizational performance and financial success (Monge et al. 1990). Data for the larger project were collected over a 67-week period in 1984 and 1985.

Surveys were distributed to a sample of employees every week for 52 weeks. The sample of employees from each company for each week was randomly selected without replacement until all employees were surveyed, after which the sample cycle was repeated. For example, in Companies B, D and E the sampling cycle was eight weeks; that is, every eight weeks everyone in these organizations completed a new questionnaire. During week #1 a randomly selected stratified eighth of all employees in these companies were given questionnaires; seven weeks later the same eighth were given a second set of the identical survey to complete. During week #2 a second stratified eighth of all employees received the questionnaires; again this second eighth received their second round of questionnaires seven weeks later. In the case of Company C the design sampled all employees every 12 weeks. In Company A the sample cycle was 26 weeks. The questionnaires were addressed to the employees constituting the sample for each week and distributed and later collected by a company employee who served as survey coordinator throughout the year. A total of 1925 employees participated in the study. Information about the sample cycles and survey response rates by company appears in Table 1.

Data representing the actual number of innovations proposed in the innovation system were collected from archival records kept by each participating organization. In some cases copies of the actual suggestion forms were analyzed; in others, company logs detailing the innovative ideas submitted were examined.

Measurement

Multiple indicators were used to represent (1) expectancies of benefits, (2) perceived inequity, and (3) participation in group communication. The three other constructs in the model were represented by single indicators: (4) perceived social pressure to contribute suggestions, (5) individual levels of information known about company commitments, problems and procedures, and (6) actual number of suggestions employees contributed to the organization.

Expectations of benefits were measured by three items which assessed individuals' expectations or beliefs about how full participation in the Scanlon system would result in personally beneficial consequences. Respondents were asked, "To what degree do you personally benefit when company commitments to (1) employees, (2) customers, and (3) financial investors are met?" For each of these three groups, respondents indicated their beliefs about the personal benefits they receive from the company's fulfillment of commitments to each group on a nine-point scale ranging from "not at all" to "a great extent." Individual expectancy scores were computed as the mean value of the three items. Reliability of this scale was $\alpha = 0.85$.

Unfortunately, this scale does not directly assess expectancies about the consequences associated with each individual's actual involvement in innovation. This operationalization measures individual beliefs about the consequences resulting from the fulfillment of company commitments to each of the three main constituents of the firm, employees, customers, and financial investors. According to the Scanlon system, fulfillment of these company commitments occurs when each organization member is fully involved and participating in the Scanlon system. In fact, company commitments to employees, customers and financial investors are only possible if the overall system "works." A critical component of a successful system is employee involvement in innovation. Thus, the question of perceived personal benefits when the company fulfills its commitments (expectancies) assumes that the respondent was instrumental in enabling the company to fulfill its commitments. Nevertheless, this scale is an indirect rather than a direct measure of expectancies associated with individual involvement in innovation. This problem of indirect measurement applies equally to our measure of perceptions of inequity.

Perceptions of inequity were derived as the difference between two sets of measures. The first set asked employees how much they SHOULD benefit when the company meets its commitments to its three main constituents: (1) employees, (2) customers, and (3) financial investors. The second set asked how much employees DO benefit when the company meets its commitments to its constituents. This set of items was the same set that formed the expectancy scale. The average value of the three

TABLE 1

Means, Standard Deviations, and Sample Sizes of Raw Data Series in Five Companies

Co.	Total Employees	Average Sample Size for Aggregate Variables	Response Rate	Sampling Cycle	Expectations of Benefits[a] $\bar{x}$ (sd)	Perceptions of Inequity[b] $\bar{x}$ (sd)	Perceived Social Pressure[a] $\bar{x}$ (sd)	Group Communication[a] $\bar{x}$ (sd)	Individual Information[a] $\bar{x}$ (sd)	Number of Innovations Contributed per Week $\bar{x}$ (sd)
A	1325	28	58%	26 weeks	7.5 (0.8)	−0.6 (0.3)	7.0 (0.8)	4.6 (1.0)	5.5 (0.8)	8.18 (5.69)
B	145	8	45	8	7.4 (0.7)	−0.6 (0.4)	6.5 (1.0)	5.3 (1.1)	6.4 (1.0)	0.58 (0.87)
C	230	15	78	12	6.0 (0.9)	−1.6 (0.7)	6.0 (1.1)	4.4 (1.0)	4.1 (1.0)	0.67 (1.67)
D	152	10	55	8	6.9 (0.8)	−0.7 (0.4)	6.7 (0.8)	5.5 (0.9)	6.1 (0.8)	0.17 (0.45)
E	93	10	86	8	7.0 (0.4)	−1.1 (0.5)	7.0 (0.5)	5.2 (0.5)	6.2 (0.5)	0.76 (1.01)

Note. None of the raw data series required detrending.

[a]These scales range from a low value of 1 indicating "not at all" or "none" to a high value of 9 indicating "to a great extent" or "very much."

[b]This scale was computed by subtracting one 9-point scale from another 9-point scale. Negative numbers indicate perceptions of underreward inequity.

difference measures formed the perceptions of inequity scale. Reliability of the inequity scale was $\alpha = 0.72$.

Group Communication was measured by asking respondents the degree to which they engaged in problem-solving discussions in a variety of organizational group settings. Specifically, respondents were asked, "In meeting our company's commitments to its customers, financial investors/owners, and employees to what extent do you use the following to participate in problem-solving? (1) department or work group meetings, (2) production committee meetings, (3) screening committee meetings, (4) meetings in other departments, and (5) meetings with your supervisor." Each of these five areas was assessed with a nine-point scale ranging from a low value indicating "not at all" to a high value indicating "to a great extent." This scale was also computed as the mean value of the five items. The reliability of this scale representing group communication was $\alpha = 0.87$.

Social pressure was measured as the degree to which individuals felt social pressure to participate in the suggestion system. A single questionnaire item asked, "In meeting company commitments to customers, financial investors/owners, and employees, to what extent do you feel accountable to develop ideas to improve productivity?" This construct was also measured on a nine-point scale with a low value indicating "not at all" and a high value indicating "to a great extent." In the Scanlon system "felt accountability" is operationally equivalent to the Fishbein and Ajzen concept of "perceived social pressure." Both terms refer to the degree to which individuals feel and accept the influence of other people in the organizational setting.

Individual information was measured by a single questionnaire item which asked, "How well informed are you about company commitments to customers, financial investors, and employees?" This construct was measured on a nine-point scale.

Involvement in innovation, the dependent variable, was measured as the total number of innovative ideas received into the innovation system in each organization. Although in some respects innovative ideas are innovations (cf. Rogers 1983), organizational innovation does not occur until the innovations have been implemented. However, to facilitate the process of organizational innovation, innovative ideas must be available, and this measure indicates the extent to which individuals are involved in an early and critical step in the innovation process.

Means, standard deviations, and average aggregate sample sizes by company are presented for each of the data series in Table 1.

Data Analysis

Data Aggregation. The present design allows for the aggregation of individual responses on each of the three motivational variables and the two communication variables into an average organizational value for a specified time period. Aggregating the individual responses by week provided 52 data points for each variable measured. Aggregating individual responses into average weekly values in order to test for individual level processes risks the ecological fallacy. However, in the present model there are theoretical issues that suggest that such aggregation may be informative without committing the fallacy. The model represents individual expectancies, perceptions of inequity, perceived social pressure, and two indications of individual communication behaviors which exist in an organizational setting. In this case, the organizational averages are derived directly from individual responses. If these variables are related within subjects, then the variables may be related between subjects, although this is not a necessary relationship. Thus, finding aggregate relationships in the data would provide support for the theories. However, failure to find the expected relationships would not necessarily refute the theories.

Nevertheless, the dynamic process in the hypothesized model may be studied at the level of organizational averages provided that causal conclusions are only applied at the same level of organizational process. The ecological fallacy is committed when individual processes are inferred on the basis of aggregate data alone. In this case, however, only the dynamic relationships between the organizational averages of the motivational variables, communication variables, and the actual number of innovations contributed to the organization are empirically examined. Our concern in the present study is to predict the actual level of innovations on the basis of aggregate motivational processes and aggregate communication processes, yet perhaps still learn something about the individual.

Time Series Model Estimation. The longitudinal data gathered in the present design invite a form of analysis that can capture dynamic processes. Time series models are able to represent temporal change in variables, as well as test causal hypotheses relating two or more data series.

In the present dynamic analysis, group level measures of the motivational variables and the communication variables were used to predict the level of innovation in the organizations. The mean value was computed for each of the five scales for each week in each company. The aggregate values for each of the five variables provided weekly summary measures of expectancy, perceptions of inequity, perceptions of social pressure, group discussions, and the level of individual information.

Time series transfer function analyses were conducted using microTSP (Lillian 1986). Transfer function analyses yield estimates of transfer function coefficients, ϕ, which relate the dependent series to one or more predictor series. They are similar to regression coefficients though they represent the dynamic and cyclical relations between the series rather than static and linear relations. It is possible to obtain a different ϕ coefficient for each time lag between the two series; in practice, only a few are statistically significant and theoretically important.

Transfer function time series analysis requires preliminary analysis of each of the series in the model. This preliminary analysis is the determination of Box and Jenkins (1976) AutoRegressive Integrated Moving Average (ARIMA) models (see also Cook and Campbell 1979, McCleary and Hay 1980, and Vandaele 1983). The autoregressive component refers to the degree that variation in a series is dependent on its own past history, both locally and cyclically. The integrated part models the trend in the data, if any exists. The moving average component represents the degree to which random error in the data in each time period influences the error in subsequent time periods.

Modeling the three ARIMA components of each series requires an iterative process which Box and Jenkins describe as identification, estimation, and diagnosis. Identification is the initial determination of an appropriate ARIMA model for a series. The identification process specifies particular autoregressive, trend, and moving average components at appropriate local and seasonal lags that represent the variation in the data series. Estimation yields actual values for each of these components in the identified model. Diagnosis is an evaluation of the adequacy of the estimated model. If an estimated ARIMA model is judged appropriate, the estimates are retained for use in the transfer function analysis. If the model is inadequate, an alternative ARIMA model is identified, estimated, and diagnosed.

Identification and diagnosis are accomplished by examining the autocorrelation functions (ACF) and the partial autocorrelation functions (PACF). The ACF is the correlation of a variable with itself at each possible time lag, i.e., the correlation of the series with itself shifted one time period for a lag one ACF, shifted two time periods for a lag two ACF, etc. Like the ACF, the PACF is the correlation of a variable with itself at each possible time lag except that it controls for all intervening time lags. For example, the lag four partial autocorrelation is the correlation between the series and itself shifted four time units, controlling for all lag two and lag three autocorrelations.

The criterion for accepting an ARIMA model is a random pattern in the residuals of the model. This pattern is called white noise and indicates that the coefficients of the estimated model capture all of the systematic variation in the data; all that remains is random variation that cannot be modeled. The Q-statistic provides a test of the randomness of the residuals (Box and Jenkins 1976).

The present model contains directional hypotheses specifying that over time the predictor variables cause innovation and not vice versa. Assessment of causal relations among longitudinal data depends upon a definition of cause developed by Granger (1980). This definition specifies that one series is a cause of another only to the extent that the first series is responsible for variation in the second series over and above the second's influence on itself. The technique for meeting the conditions of Granger causality consists of statistically removing (partialing) the influence of the dependent variable's past history on itself before determining the effect of the predictor variables on the dependent variable. This process is called prewhitening or filtering of the dependent variable. In the present data, the dependent variable was prewhitened prior to the transfer function analysis.

The transfer function analysis, which relates the independent series to the dependent series by the criterion of Granger causality, was based upon examination of the correllogram, which contains all contemporaneous and lagged cross correlations. Significant cross correlations indicate which lagged coefficients should be estimated in the final model. The estimates of the transfer function coefficients, ϕ, indicate how much each predictor variable at each significant time lag causes variation in the dependent variable over and above the dependent variable's own history, i.e., its own ARIMA structure. Estimates are also provided to describe the ARIMA structure for each predictor variable.

Tests of the Time Series Model. After the model was estimated by the above procedures it was tested for statistical adequacy. First, each hypothesis was tested by examination of the significance of the transfer function coefficients at the traditional $\alpha = 0.05$ level. Second, the overall R^2 was examined to determine how much variation in innovation was explained by the predictors over and above the variance explained by the univariate ARIMA model for innovation, i.e., by the past history of the dependent series. Since these R^2 values are additive, the univariate explained variance in the dependent variable is equal to total R^2 minus incremental R^2. Third, the adequacy of the model was also assessed in terms of "post-sample" forecasting (Granger 1980). The hypothesized model was re-estimated using the first four-fifths of the sampling time frame, 42 weeks. The model estimated was then used to forecast values of the variables for the remainder of the sampling time frame, the remaining ten weeks. The forecasts were compared with the actual data for the last 10 weeks. The mean percentage forecast accuracy, computed as the sum of the ten forecast accuracy values divided by ten, was used as an indicator of the forecasting ability of the hypothesized model.

Results

Univariate Models for Each Variable

The specific autoregressive, integrated moving averages (ARIMA) models obtained for each of the series in each organization, A through E, are shown in Table 2. For each of the six variables (the five predictor variables and the dependent variable, innovation), statistically significant ARIMA coefficients are provided.

TABLE 2

Univariate ARIMA Coefficients and Variance Explained (R^2) for Each Data Series in Five Companies

Company	Expectancy of Benefits	Perceptions of Inequity	Perceived Social Pressure	Group Communication	Individual Information	Innovations
A	AR(13) = 0.48* (0.18) R^2 = 0.17	R^2 = 0	R^2 = 0	AR(2) = 0.96* (0.18) SAR(12) = − 0.53* (0.14) MA(2) = − 0.67* (0.24) R^2 = 0.47	R^2 = 0	AR(1) = 0.58* (0.14) R^2 = 0.33
B	AR(1) = 0.29 (0.15) AR(6) = 0.45* (0.16) R^2 = 0.26	AR(1) = 0.31 (0.16) R^2 = 0.10	R^2 = 0	AR(7) = 0.45* (0.16) R^2 = 0.18	AR(3) = −0.50* (1.0) MA(7) = 0.44* (0.17) R^2 = 0.25	AR(3) = 0.34* (0.17) R^2 = 0.10
C	R^2 = 0	R^2 = 0	R^2 = 0	AR(2) = 0.56* (0.17) R^2 = 0.22	AR(7) = − 0.42* (0.18) AR(11) = − 0.54* (0.19) R^2 = 0.28	AR(4) = 0.37* (0.16) R^2 = 0.25
D	R^2 = 0	R^2 = 0	AR(1) = −0.38* (0.16) R^2 = 0.15	AR(7) = 0.37* (0.17) R^2 = 0.13	R^2 = 0	R^2 = 0
E	R^2 = 0	MA(9) = −0.86* (0.18) R^2 = 0.56	MA(9) = −0.90* (0.16) R^2 = 0.68	R^2 = 0	R^2 = 0	MA(3) = − 0.81* (0.21) R^2 = 0.39

Note. AR = autogressive and indicates the extent to which the variable depends on its own local past history. SAR = seasonal autoregressive; it is similar to an AR coefficient except that it refers to dependency on past history on a more macro, seasonal level. MA = moving average. The moving average term indicates the extent to which errors at one point in time carry over to influence errors at other points in time. The number in parentheses following each ARIMA term is the time lag in weeks. Numbers in parentheses under the ARIMA coefficients are the standard errors of the coefficients. $R^2 = 0$ indicates that there is no systematic over time variance in the series. It is a random variable known as white noise that does not need to be modeled by ARIMA coefficients.

*$p < 0.05$.

The order of the significant autoregressive and moving average terms was determined empirically through the Box-Jenkins process of identification, diagnosis, estimation, and reidentification. The specific lags in the univariate models typically reflect organization practices in the corresponding organization. The following paragraphs describe the univariate results for each variable in each company reported in Table 2.

Company A. The presence of a statistically significant AR(13) component equal to 0.48 for expectancy of benefits reflects the recurring pattern of expectation brought about by the company practice of paying bonuses on a quarterly basis (i.e., every 12–13 weeks). Likewise, the statistically significant AR(2) component equal to 0.96 for group communication indicates that people typically participated in group meetings on a biweekly cycle. The effect of the quarterly Scanlon committee meetings is reflected in the presence of a statistically significant SAR(12) component. The presence of a statistically significant AR(1) component for innovation indicates that the number of suggestions submitted by employees at Company A was related from one week to the next.

Company B. A significant AR(6) = 0.45 component for expectancy of benefits suggests that employees' contemporary expectancies were related to those six weeks prior. The presence of a significant AR(7) component equal to 0.45 for participation in group communication reflects a seven-week cyclical pattern of group communication. The presence of an AR(3) = −0.50 component for individual information suggests that there is a three-week oscillating cycle in the average level of information available to employees. This pattern may be due to regularly appearing reports or informational meetings. Finally, the AR(3) component equal to 0.34 for innovations indicates that innovations are contributed in a three-week cyclical pattern.

Company C. The significant AR(2) component of 0.56 for group communication reflects a biweekly cyclical pattern in holding meetings. The AR(4) = 0.37 component for innovation indicates that employees in Company C submit suggestions on a monthly cycle.

Company D. A significant negative AR(1) = −0.38 component for social pressure suggests that employees' perceptions of social pressures oscillate. Since no bonuses were paid in Company D during the year of this survey, this flip-flop in employees' perceptions may have resulted from employees' vacillation toward the innovation system. The AR(7) = 0.37 component for group communication indicates a seven-week cycle.

Company E. None of the six processes had any autoregressive components. However, there were moving average components associated with perceptions of inequity, perceived social pressure and the number of innovations. The presence of an MA(9) coefficient for perceptions of inequity suggests that a random disturbance that altered the employees' perceptions of inequity in a particular week influenced the same process nine weeks later. The MA components for perceived social pressure and innovation can be described in a similar fashion. However, the interpretation of these MA coefficients is not easy to discern (Vandaele 1983).

As indicated at the beginning of this section, R^2 values for the univariate models are also shown in Table 2. Series that are white noise processes are indicated by $R^2 = 0$. The R^2 values for the six univariate series that were modeled with ARIMA coefficients ranged from 10 percent to 68 percent. These results indicate the periodicity of some of these series over time. In four of the five companies, the weekly series for group communication and/or innovation had periodic patterns reflecting the routinely scheduled workgroup and screening committee meetings, respectively. In two companies that paid bonuses during the year in which the survey was conducted, employees' expectancy of benefits displayed periodicities matching the payment of the bonus. Further, in two of the five companies, individual information among employees corresponded to the periodicity of Scanlon committee meetings. However, employees' perceptions of inequity and social pressure displayed no periodicity in four out of the five companies.

Individual Hypotheses and the Overall Model

The estimates for the hypothesized transfer function coefficients, ϕ, for the model for each of the five companies are shown in Table 3. These coefficients represent the relation between each predictor variable and the dependent variable, innovation. The rest of this section reports the values of the ϕ coefficients for the five research hypotheses that comprise the model of the dynamics of organizational innovation. Also provided is the amount of explained variance (R_2 and ΔR^2) and the forecasting adequacy of the overall models for each of the five firms.

Hypotheses H_1, H_2, and H_3 stated that increases over time in individual motivation resulting from employees' expectations of benefits (H_1), perceptions of inequity (H_2), and perceived social pressure (H_3) would cause subsequently higher levels of organizational innovation. The results reported in the first three columns of Table 3 indicate an almost universal absence of statistically significant causal coefficients linking the three series representing motivational influences. Only in Company E were there significant causal links from employees' perceptions of inequity and social pressure to the number of innovations. In Company E, employees' perceptions of inequity were negatively related to the number of innovations ($\phi = -1.1$, $p < 0.05$). In this one company the relationship between inequity and innovation was consistent with hypothesis H_2. However, the causal link between social pressure and the number of innovations contributed was unexpectedly negative ($\phi = -0.88$, $p < 0.05$) and therefore fails to support hypothesis H_3. With the one exception in the model for Company E, the results do not support hypotheses H_1 through H_3 which relate expectation of benefits, perceptions of inequity and social pressure to involvement in innovation.

Hypotheses H_4 and H_5 stated that, over time, higher levels of group communication and increased levels of information would cause subsequently higher levels of organizational innovation. As predicted, and as shown in columns 4 and 5 in Table 3, in four of the five organizations statistically significant and positive causal relationships existed from one or both of the series representing group communication processes and individual levels of information to the level of innovation.

In Companies A, C, and E the level of employees' information was significantly and positively related to the level of innovation. This causal link was not found in Companies B and D. In Companies B and E the level of involvement in group communication was significantly and positively related to the level of innovation. These findings are consistent with hypotheses H_4 and H_5. The level of group communication was not related to innovation in Company C. In the case of Companies A and D, while the causal link between group communication and innovation was significant, in both of these companies the coefficient was negative. This finding was not predicted. Figure 2 shows the empirical model for each company; only significant causal paths are shown.

The overall fit of the hypothesized model was assessed in terms of the R^2 values for the endogenous variable, the number of innovations contributed. The R^2 values are reported in the right-hand column of Table 3. They varied from a modest 30 percent in Company C to a very large 78 percent in Company E. With the exception of Company C, the proportion of the total variance in organizational innovation explained by the five predictor variables (ΔR^2) ranged from a low of 34 percent in Company A to a high of 43 percent in Company D. In Company C, the five predictor

TABLE 3

Transfer Function Coefficients (ϕ), Total Variance Explained (R^2), and Incremental Change in Variance (ΔR^2) in the Model Predicting Innovation in Five Companies

Company	H_1: Expectancy	H_2: Inequity	H_3: Social Pressure	H_4: Group Communication	H_5: Individual Information	Total R^2 Incremental R^{2a}
A	$\phi = 0.72_{t-11}$ (0.87)	$\phi = -0.56_{t-1}$ (2.3) $\phi = -0.63_{t-9}$ (2.8)	$\phi = 0.47_{t-2}$ (1.1) $\phi = 1.4_{t-3}$ (1.2) $\phi = 1.5_{t-7}$ (1.2)	$\phi = 0.88_{t-1}$ (0.81) $\phi = -2.0_{t-3}{}^*$ (0.76) $\phi = -1.9_{t-11}{}^*$ (0.77)	$\phi = 2.1_{t-1}{}^*$ (1.0)	$R^2 = 0.67$ $\Delta R^2 = 0.34$
B	$\phi = 0.28_{t-1}$ (0.26) $\phi = -0.31_{t-11}$ (0.28)	$\phi = 0.51_{t-2}$ (0.44) $\phi = -0.02_{t-9}$ (0.43)	$\phi = -0.07_{t-2}$ (0.17) $\phi = -0.26_{t-5}$ (0.15)	$\phi = 0.41_{t-2}{}^*$ (0.17) $\phi = 0.01_{t-5}$ (0.17) $\phi = -0.10_{t-8}$ (0.16)	$\phi = 0.18_{t-1}$ (0.20) $\phi = -0.36_{t-2}$ (0.26) $\phi = 0.02_{t-12}$ (0.21)	$R^2 = 0.51$ $\Delta R^2 = 0.41$
C	$\phi = -0.13_t$ (0.43)	$\phi = -0.27_t$ (0.46)	$\phi = -0.11_{t-3}$ (0.37)	$\phi = -0.11_{t-3}$ (0.43)	$\phi = 0.56_{t-1}{}^*$ (0.26)	$R^2 = 0.30$ $\Delta R^2 = 0.05$
D	$\phi = 0.14_{t-1}$ (0.08)	$\phi = -0.06_{t-2}$ (0.20)	$\phi = -0.12_{t-3}$ (0.08) $\phi = 0.09_{t-4}$ (0.07)	$\phi = -0.16_{t-6}{}^*$ (0.08)	$\phi = -0.02_{t-2}$ (0.09)	$R^2 = 0.43$ $\Delta R^2 = 0.43$
E	$\phi = 0.22_{t-5}$ (0.29)	$\phi = -1.1_{t-7}{}^*$ (0.35)	$\phi = -0.88_{t-4}{}^*$ (0.20)	$\phi = 0.85_{t-9}{}^*$ (0.26)	$\phi = 0.43_{t-4}{}^*$ (0.21)	$R^2 = 0.78$ $\Delta R^2 = 0.39$

Note. Transfer function coefficients, like regression coefficients, represent the relation between each of the five predictor variables and the dependent variable, innovation. The subscript expressions "t-number" indicates the time lag, in weeks, at which the coefficients were included in the model. The numbers in parentheses under the coefficients are the standard errors.

[a] ΔR^2, the incremental R^2, indicates the amount of variance added by the predictor variables over the variance accounted for by the past history of the dependent variable as modeled by its ARIMA structure. The amount of explained variance provided by the ARIMA coefficients is provided in the right-hand column of Table 2. The sum of the variance explained by the ARIMA coefficients and the variance explained by the ϕ coefficients for the predictor variables equals the total explained variance, R^2, as reported here in the right-hand column.

$^*p < 0.05$.

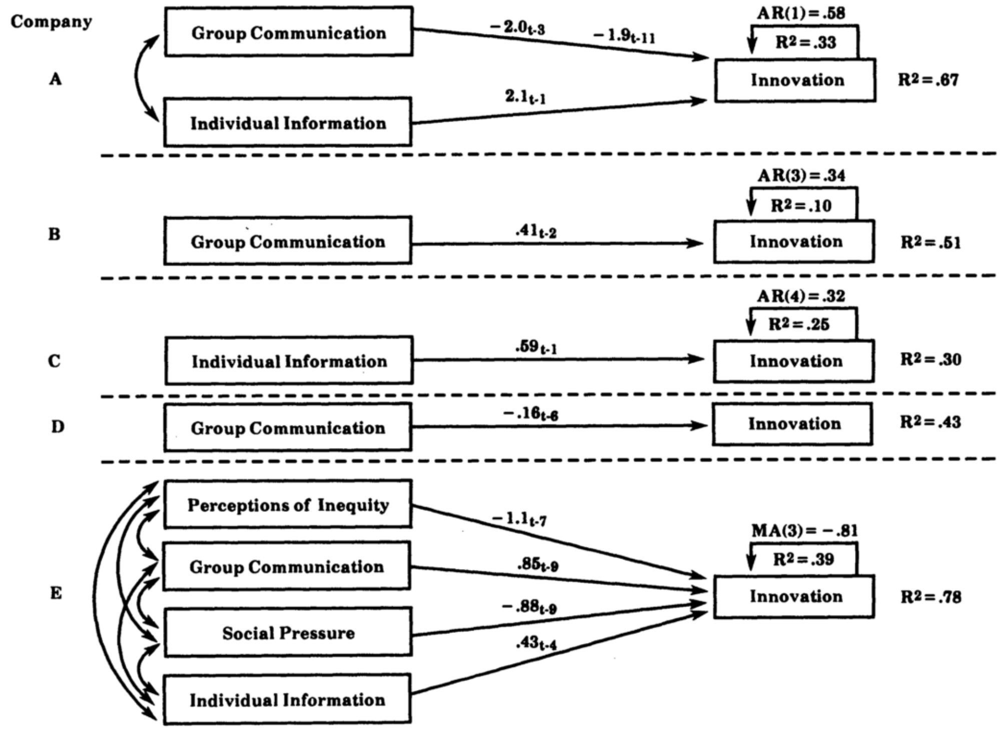

FIGURE 2. Results Predicting Levels of Innovation in the Five Companies. ϕ coefficients are reported on the arrows leading from predictor variables to the dependent variable, innovation. All reported ϕ coefficients are statistically significant at $p < 0.05$; nonsignificant links have been deleted from this figure but the values for the coefficients are reported in Table 3. Statistically significant ARIMA coefficients representing the past history of the dependent variable are reported on the top of the feedback arrows. The amount of variance in the innovation variable explained by these ARIMA coefficients is reported as the R^2's within the feedback arrow. The R^2's on the right-hand side of the models report the total variance in the level of innovation explained by the entire model, i.e., by the ϕ and ARIMA coefficients.

variables accounted for a meager 5 percent of the total of 30 percent explained variance.

Finally, the adequacy of the model was assessed in terms of post-sample forecasting. The model forecasts for the last ten of the 52 weeks were compared to actual scores for the corresponding time period (weeks 43–52). Table 4 indicates the mean and the standard deviation of the mean absolute percentage forecasting accuracy for the level of involvement in the innovation system in each of the five companies. For four of the five firms the forecast accuracy ranged from a low of 77 percent to a high of 85 percent. For the fifth company (C) the forecast accuracy was 38 percent, as would be expected on the basis of the lower explained variance in this firm.

Discussion

The research model presented in this paper was based on the theory of reasoned action, equity theory and communication theory and research. Previous investigations have attempted to examine each of these theories in isolation. In the present research we posited that elements of each theory would contribute to the explained variance in innovation, thereby providing a fuller explanation of the process than any one theory could give. The results showed little support for the contribution of equity theory and for the theory of reasoned action. By contrast, the communication and information variables contributed extensively to the explained variance in innovation.

TABLE 4
Mean Absolute Forecast Percentage Accuracy for Innovation

Company	Forecast Accuracy[a]
A	79%
	(16)
B	77%
	(16)
C	38%
	(39)
D	83%
	(15)
E	85%
	(12)

[a]Standard deviations in parentheses.

The universal lack of support for the role of expectancy beliefs posited by the theory of reasoned action is troubling. The expectancy model has generally been found to predict those behaviors governed by clear choice situations. Certainly, it seems reasonable to believe that individuals must choose to offer suggestions and that they "expect" some sort of beneficial outcome as a result of their choice. Nevertheless, in the aggregate, expectancies were not related to innovation. This finding may be due in part to the fact that a relatively few individuals offered the majority of suggestions. In each of the five companies over 60 percent of the employees never offered a suggestion over the year of the research project. Thus, individual motivational processes affecting the relatively few employees who offered suggestions may have been masked by the larger number of employees who did not offer suggestions for reasons other than expectancies, equity, or social pressure.

However, there are at least two additional explanations for the apparent lack of relationship. First, as discussed previously, the mathematical process of aggregating individual expectancy beliefs into an average value may mask an existing individual level motivational process. This kind of aggregation does not guarantee that relationships between the variables of expectancies and innovation that may exist within individuals will be preserved when estimated across individuals.

A second explanation for the lack of support for H_1 is that our operationalization of the expectancy beliefs construct was not focused directly on the generation of innovations by employees. The measure was clearly indirect. Thus, inadequate measurement may explain our failure to find support for this hypothesis (see Cooper and Richardson 1986).

The lack of a significant relationship between perceptions of inequity and the level of innovation may also be the result of the indirect measures of inequity with respect to innovation involvement. Alternatively, the results are consistent with the conclusions of Goodman and Friedman (1971) who stated that equity theory has consistently been a better predictor of attitudinal outcomes than performance measures. The results of this study appear to support Landy and Becker (1987), who more recently argued that "there seems to be little compelling logic for directly examining work performance as a dependent variable in equity research" (Landy and Becker 1987, p. 28). The present research suggests that this claim may also be true for the level of innovativeness in the firm.

However, the significant effect of employees' perceptions of inequity on the level of innovation in Company E suggests an alternative explanation for these findings.

Perhaps the impact of perceived inequity on involvement in innovation is contingent on some aspect of the immediate organizational context. For example, Table 1 indicates that, in Company E, employees' perceptions of inequity were very high (-1.1) and surpassed only by employees at Company C (-1.6). If employees have a nonzero threshold tolerance for perceptions of inequity (Contractor 1988, Cosier and Dalton 1984) it is possible that employees' perceptions of inequity at Companies A, B, and D did not cross that threshold. This would account for the apparent lack of support for H_2 in these three companies and the existence of support in Company E. Unfortunately, H_2 was not supported at Company C where employees' perceptions of inequity were even higher than those in Company E. Thus, it is not clear why perceptions of inequity were important in Company E, but apparently not important in Companies A through D. Furthermore, the problems of aggregation may be affecting this result, as in the case of the expectancy variable.

Contrary to hypothesis H_3, the results indicate no evidence that employees' perceptions of social pressure to contribute had a positive impact on the level of innovation. In fact, in Company E perceptions of social pressure had a significant negative influence on the level of innovation four weeks later. This anomaly can be understood in terms of the organizational context. In the first quarter after joining the Scanlon Plan, Company E had registered profit increases of 300 percent. Despite the flattening of profits for the subsequent dozen quarters, it is reasonable for employees in Company E to perceive a strong normative pressure to emulate their earlier performance. In fact, among the companies surveyed, employees at Company E reported the highest amount of social pressure. However, the advent of a radical innovation at Company E (large-scale computerization of the printing press) may have eliminated or at least stalled the employees' ability to generate the incremental innovations. Hence, despite mounting social pressure to innovate, employees were losing their ability to contribute influential suggestions. Such a predicament would account for the anomalous negative relationship between perceived social pressure and the level of innovation found in Company E.

While the lack of support for the positive role of motivational processes was theoretically discouraging, the significant role of communication processes was extremely interesting. In four of the five organizations, one or both of the communication series was positively related to the actual level of innovation. In two of the companies (B and E), participation in group communication was positively related to subsequent levels of innovation. These findings support the theoretical explanation that interaction, feedback and access to more information in the group situation would lead to greater levels of innovation (Tjosvold and McNeely 1988). However, the differences in lag times in the two companies where H_4 was supported warrant closer examination.

For Company B, an increase in group communication was accompanied by an increase in the level of innovation two weeks later. In Company E nine weeks elapsed before an increase in group communication caused an increase in the level of innovation. An examination of the univariate models for Company E (see Table 2) indicates the absence of any autoregressive periodicities. In its implementation of the Scanlon Plan, Company E relied more on informal structures than formal periodically scheduled meetings. In the absence of any formally scheduled meetings, it is plausible that employees' participation would have a slower impact on the level of innovation.

The results of the test of H_4 in Companies A and D are troubling. In these two companies the level of group communication was negatively related to the subsequent level of innovation. This finding runs opposite to the predictions and may indicate that the hypothesized relationship between group communication and innovation is too general. For example, hypothesis H_4 may be true only under a relatively few organizational circumstances. However, under some organizational conditions as in the present two cases, the relationship operates in the opposite direction. For example, suppose that increased levels of communication in Companies A and D resulted in the discovery of solutions to organizational problems. Solutions discovered as a result of group discussions could be implemented directly. Innovative ideas of this type would never be formally introduced into the innovation system. In fact, when real problems are being solved via informal communication processes one might expect a decline in individual participation in a formal system designed to gather innovative ideas.

Alternatively, the nature of some kinds of group discussions may actually lead to a resistance toward innovation. Unfortunately, these data do not provide sufficient information to establish either of these two possible explanations. Thus we are left to conclude that the true relationship between group communication and innovation is unclear.

In three companies (A, C and E) individuals' level of information predicted innovation in the hypothesized direction. This finding is consistent with the work of Tushman (1977), Ebaldi and Utterback (1984), Katz (1982), Keller (1986), Kanter (1982, 1988a) and others who showed the importance of access to information in the innovation process. Greater access to information provides individuals with more resources by which to create innovations. In Companies A and C an increase in the level of information caused an increase in the level of innovation in the subsequent week. However in Company E, where the informal arrangements appeared to slow down the processes, an increase in individuals' level of information took four weeks to cause an increase in the suggestions submitted.

Advantages of the Longitudinal Research Design

The present research represents a unique approach to the study of communication and innovation in a field setting. While many have suggested the use of time sensitive methodologies (Monge 1990), there are very few examples to be found in the published literature (Monge et al. 1984, Van de Ven and Rogers 1988). The present study captures a substantial part of the process of innovating in terms of a dynamic causal model. The estimation of the transfer function model offers a straightforward way to test hypotheses about specific causal links between variables. The longitudinal design employed in this study has at least four distinct advantages.

First, the method allows an estimate of the degree to which the dependent variable, innovation, can be predicted from past levels of innovation. The findings showed that the variance in innovation explained solely by past levels of innovation for the five companies was between 0 and 39 percent.

Second, the methodology allows for the study of causal relationships after controlling for the predictability of each series based on its own past. In the present study the addition of the hypothesized predictors resulted in incremental increases in the variance explained in innovation from 5 percent to 43 percent. While the interpretation of R^2 values in time series models must be done with care, the substantial increases in the explained variance are a statistically based indication that communication is vital to the innovation processes.

Third, the methodology allows assessment of the accuracy of post-sample forecasting. The results presented in Table 4 show that with the exception of Company C, the level of percentage forecast accuracy in innovation is consistently high, 77 to 85 percent. This statistical method of evaluation also confirms the important role of communication in the process of innovation.

Fourth, the methodology provides an opportunity to provide conclusive evidence of time-ordered causality. The presence of several lagged predictors of the level of innovation is significant and intriguing. The existence of lagged causal relationships is significant because they eliminate the ambiguities associated with cross-sectional correlations and contemporaneous dynamic correlations (Granger 1980). They are intriguing because their interpretation may necessitate a closer and thicker description of the local organizational practices.

Limitations and Suggestions for Future Research

There are several limitations to the present research. First, as discussed earlier, data were aggregated across individuals to provide organizational level results. Although we have made a case as to why this procedure is justified, we have no empirical evidence that supports the argument other than the results themselves. It is important to test this assumption in future work. One possibility is to invite a panel of employees to provide their independent responses every week, thereby providing a basis for comparing individual with aggregated responses.

Second, time series statistical theory assumes that several variables are measured at many points in time. Each of these series is considered to be a "realization" of the underlying processes that generated them. This concept is roughly equivalent to the notion of a sample statistic representing a population parameter at a certain level of precision in traditional inferential statistics. However, time series methodology focuses primarily on variation across time not variation across individuals. Currently, no techniques are available that permit the estimation of time series coefficients for multiple series AND multiple individuals. In a sense, the decision to aggregate data is almost mandated by the current limitations of the technique. This situation is likely to change in the not too distant future as statisticians provide the requisite theory and algorithms (Anderson 1978).

It is tempting to conclude that time series research should be reserved for macro level organizational variables or only for those situations in which the legitimacy of aggregation has been demonstrated. However, even this is not a very satisfying conclusion, as can be illustrated with the present research. Our sample consisted of about 2000 respondents in five organizations. From a time series perspective it is these five sets of series that constitute five realizations of the underlying processes. Even in this case an established technique does not exist for aggregating the separate results. In previous analyses of these data (Contractor 1988, Monge et al. 1990), we utilized meta analysis to aggregate the ϕ coefficients and to establish statistical confidence intervals around these parameters. While this strategy provided useful results, it added another layer of statistical procedures on an already complex set of techniques. In every analysis one eventually arrives at a point of diminishing returns, and meta analysis of transfer function coefficients appears to be getting dangerously close to that limit.

Third, since the study extended over a 52-week period it failed to detect patterns in organizational processes in excess of one year. Collection of data over time periods significantly greater than one year (perhaps, five to ten years) would provide researchers with an opportunity to examine the effects on organizational innovation of (1) organizational level phenomena, such as annual trends or cycles in production and sales figures, (2) industrial level phenomena, such as industry-wide profitability figures, and (3) national phenomena, such as election year cycles. For instance, of the five companies in the present study, employees at Company C had the lowest expectancy beliefs, highest perceptions of inequity, lowest perceived social pressure, lowest participation in group communication and the lowest level of individual information. Further, the level of innovation was only predicted by the level of information. The present study, limited to a 52-week period, is ill-equipped to uncover the dynamics that resulted in the status quo at Company C.

Fourth, although the present study was conducted in multiple organizations, they represent a very selective sample from the population of organizations. All of the organizations surveyed were located in the United States and all had implemented the Scanlon Plan. Therefore, it is not appropriate to generalize on the basis of this study to companies that do not subscribe to the Scanlon philosophy of participative management. Our inability to accurately forecast innovation in Company C, which had not wholeheartedly endorsed the Scanlon Plan, fuels our caution. Future research should be conducted in non-Scanlon companies.

Finally, despite the fact that our theoretical formulation has been informed by cross-sectional studies of organizational innovation it is important to distinguish between the knowledge claims associated with cross-sectional and dynamic causal models of organizational innovation. For example, a cross-sectional study of organizational innovation typically hypothesizes that organizations where employees have higher levels of participation in group communication (as compared to employees in other organizations) will also have systematically higher levels of innovation. In contrast, the corresponding causal link in the model proposed in this study tested two hypotheses. First, it tested the hypothesis that the level of innovation in an organization was related to itself over time. Next, it tested the hypothesis that, in addition to being predicted by its own past, an increase in the level of organizational innovation would also be predicted by an increase in contemporaneous and past levels of group participation among the employees. As a result of this distinction between cross-sectional and dynamic studies it is possible to reconcile what may appear to be conflicting findings for the same theory based on cross-sectional and dynamic studies. This distinction, accompanied by the paucity of innovation research based on dynamic causal models, further enhances the unique contribution of this study. While future research should clarify the anomalous findings reported here, we view the present work as a promising step in the right direction.

There are a number of managerial implications that can be gleaned from the results of this study. First, the Scanlon system places a premium on providing information about all aspects of the firm. The results of this research support the crucial role that information plays in generating innovations. People who are responsible for managing innovation systems in firms should develop systematic means for sharing a wide range of information. This includes generalized information about all aspects of the firm and its stakeholders as well as information about specific problems that innovations will help to resolve. Second, the results indicate that under some circumstances group communication can increase innovation. Consequently, managers should encourage a wide variety of carefully planned meetings, conducted under norms that facilitate a thorough discussion of all sides of the issues. Third, innovation is a dynamic process that occurs over time. It fluctuates in accordance with other processes. Managers need to be sensitive to the cycles that occur in the innovation process, varying from peaks to troughs at various times across the years. At some points during the year the innovation process may need additional managerial focus and emphasis to help it through a low period. At peak times it may need little managerial attention. Finally, when viewed over time, motivation might be a very difficult phenomenon to sustain. Managers should plan regular and sustained efforts to encourage the level of motivation necessary for people to contribute innovations on a regular basis.

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