A BEHAVIORAL MODEL OF

PROFESSIONAL PERFORMANCE

by

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ABSTRACT

All profit-oriented companies have procedures for the evaluation of employee performance and the administration of salary increases and promotions. These procedures not only affect the individual's motivation to work, they also affect his interaction with other employees. This is particularly important in professional organizations where the cohesiveness of project teams and the flow of technical knowledge are essential in order to maintain high standards of performance.

A systems analysis is undertaken of a typical evaluation policy and its effect on professional performance. The techniques of Industrial Dynamics are employed to obtain an overall picture of system behavior of the professional organization.

It is concluded that if management does not directly concern itself with the extent of interaction among its staff members, situations can develop which may be detrimental to company goals. In particular, above average employees do not use their time effectively and are not as productive as they might be. Below average employees tend to compete with their colleagues in their striving for higher performance ratings. A revised model in which the company controls interaction helped improve system behavior.

Thesis Supervisor: Edward B. Roberts
Title: Associate Professor of Management
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CHAPTER I

PERFORMANCE APPRAISAL IN PROFESSIONAL ORGANIZATIONS

One of the major concerns of any business organization is the administration of wages and promotions to its employees. Traditionally this is accomplished by evaluating each individual's performance and comparing it with company expectations and goals. An individual whose evaluation is "high" is rewarded with wage increases and promotions, whereas a "low" evaluation results in pressure being exerted on the individual to improve his performance or face job termination. The process of evaluating an employee's performance and the subsequent rewards or pressures offered him will be referred to in the remainder of this thesis as the company's appraisal-incentive policy. This process can be quite complex and in many cases it is highly subjective.

The appraisal-incentive process is complicated even further when the functions of the employee are very loosely defined and he has a high degree of autonomy. Excellent illustrations of this type of employee-company relationships are exhibited by consulting firms, research and development organizations, and in general, the "knowledge industry," as it has been referred to in Fortune magazine.¹

Companies in the knowledge industry usually employ a staff of highly-trained skilled professionals. It is the combined knowledge and experience of its staff which is the salable commodity of the organization. For example, a research and development firm is awarded a government contract primarily when it can demonstrate that its staff has the know-how to handle the technical difficulties which may be encountered in completing the contract. A consulting firm is approached only after it has demonstrated the ability of its staff to solve problems too complicated for obvious detection. A college mathematics department attracts the best students only after it has established a reputation that its professors are highly qualified in their respective fields.

In these three types of organizations the individual staff member, whether working alone or in project teams, is the heart of the firm. Often he is the sole representative of the company in its customer relations. On his shoulders rests the integrity, the competence and the reputation which the company enjoys.

The functions of the staff member are usually two-fold. First, he is responsible for securing contract awards. To achieve this goal, he must write proposals to potential customers indicating the advantages of his particular firm in performing the desired work. These proposals can either be solicited or unsolicited. A solicited proposal is written in response to a request for proposal (R.F.P.) from the customer; an unsolicited proposal is written in hopes of persuading a government contracting agency to initiate a contract. When preparing a solicited
or unsolicited proposal, the staff member often works by himself or in conjunction with other staff members.

If the proposal is successful and a contract is awarded, it then results in an "in-house" contract. In most circumstances, contracts are processed by project teams consisting of professional staff members, technicians and clerical aids, who work together until the project is terminated or the contract completed. The joint effort of many individuals is usually required to successfully complete a contract although during the course of the project new people may join the team and others may leave.

This thesis is concerned with the effects and implications of an appraisal-incentive policy on the overall performance of a professional staff member in the knowledge industry. It attempts to relate not only the direct and immediate effects of an appraisal-incentive policy on individual motivation but also to explore the effects of such a policy on the interactions and extent of cooperation among professional employees.

In particular this thesis investigates three situations which the author feels often result from typical appraisal-incentive policies.²

1.) Many companies in the knowledge industry, especially in research and development, are expansion conscious. They will bid on any contract in their field, often without considering the implications of this attitude on the professional staff. As one company owner expressed, "We are growth

² From observations made by the author while working in the Knowledge Industry.
oriented. Any contract we can get we will bid on. If more production capacity is needed, we will get it. Right now, we are held back from expanding only by the number of contracts we can win." This type of company attitude is reflected in the appraisal-incentive scheme in that employees are evaluated primarily on their ability to write proposals in the hopes of securing contract awards. Often this results in inferior quality work, as the employee devotes too much of his time and effort preparing proposals rather than attempting to attain maximum performance and utility in the contracts on which he is working. It is hypothesized that an evaluation process which puts a premium on proposal writing, at the expense of quality contract work, will in the long run have a detrimental effect both on the motivation of the professional staff member and on the company goal of achieving a high growth rate.

2.) Professional organizations are often not concerned with keeping the staff member posted as to "how well he is doing." A professional employee may not know by what standards he is being evaluated. Although there may be much communication between management and staff as to purely technical matters, there may be very little communication on a personal "buddy-buddy" basis. Douglas McGregor has suggested that this type of personal attention from management is essential in providing proper direction for the employee's efforts.\(^3\) It is hypothesized that the lack of up-to-date personal communication between management and the

staff member as to what exactly are the goals of the organization and what are the standards by which his performance is being evaluated, often results in a disequilibrium in goal setting. Thus the goals of the company, as reflected in the evaluation process, may not be the goals of the individual.

3.) The situation which is investigated most thoroughly in this thesis concerns the effect of the appraisal-incentive policy on the extent of interaction among the staff members. A company can often be characterized by the social atmosphere and environment in which its employees function. In some professional organizations an atmosphere of competition exists within the ranks of the staff members. There is little social communication, an unwillingness to share technical knowledge, poor group cohesiveness and a general attitude of each individual striving to out perform his colleagues in order to achieve higher performance ratings.

On the other hand, some companies maintain a casual informal atmosphere. An atmosphere in which there is a great deal of voluntary cooperation, constant "bull-sessions" where ideas are freely exchanged, and in which groups work very cohesively. Carried to an extreme, this often results in costly inefficiency and low rates of productivity as too much time is spent on non task-oriented activities.

Yet many companies in the knowledge industry blithely ignore the extent of interaction among the staff members unless it becomes extremely competitive (a dog-eat-dog atmosphere) or extremely casual (a daily eight-hour coffee break). These companies assume "natural forces" will prevent
the extent of interaction from reaching these extremes. It is hypothesized that unless the professional organization takes an active interest in maintaining some standards of interaction, social environments can develop which are detrimental to individual motivation and company objectives. Particularly this thesis explores the idea that "natural forces" exist which somehow curtail or prevent excessively low interaction or excessively high interaction.

In order to investigate these three hypotheses a complex feedback model of the interaction of the key variables is constructed. This model is used to trace the casual relationships which exist in the system. The model is expressed in terms of linear difference equations using the DYNAMO computer language. The results of the simulation runs are then analyzed in order to understand the way in which the feedback loops interact to determine the behavior of the model. By making changes in the model, new simulations can be run and these can be compared with the basic run in order to test the validity of the three hypotheses. Where possible, changes are made in the company's appraisal-incentive policy in order to improve system behavior.
CHAPTER 2

A SYSTEMS ANALYSIS OF PROFESSIONAL PERFORMANCE

The relationship between top management and the professional staff of a company in the knowledge industry can have a great effect on establishing the social environment within which the staff members function. Company environments cover a broad spectrum from the casual, shirt-sleeve, friendly atmosphere to the formal, rigid, strictly business atmosphere. The extent of social interaction between the staff members is one of those intangible factors\(^1\) which appears to be of much consequence in effecting the motivation of the individual staff member.\(^2\)

It was until the late 1930's that management became concerned with intangibles, such as the motivation of its employees. In a company which depends almost exclusively on its professional personnel, motivation, satisfaction, cohesiveness, etc. are almost as sound indicators of company "health" as is the balance sheet. Although many psychologists and sociologists have collected data on these behavioral characteristics, it was only in 1960 that this data was interpreted and a meaningful, practical philosophy of management-employee relationships was organized by Douglas McGregor.\(^3\) In his book, The Human Side of Enterprise, McGregor compares

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\(^1\)Edward B. Roberts, "New Directions in Industrial Dynamics". (The Industrial Management Review, Alfred P. Sloan School of Management, M.I.T., Fall 1964).


the old, traditional theory of management, which he refers to as Theory X, with a new theory he develops from the accumulation of knowledge about human behavior. The old Theory X states that man will always seek to avoid work, has little ambition or self-motivation, and therefore must be coerced or pressured to put forth effort toward the achievement of organizational goals. It seems natural that this theory would lead to the formal, strictly business atmosphere mentioned earlier, in which individuals would produce for fear of losing job security and not for promotions and greater responsibility.

However, many recent psychological studies of human behavior indicate that there are "inconsistencies inherent in Theory X." Utilizing the growth of knowledge in the social sciences during the last twenty-five years, Professor McGregor formulated Theory Y. Theory Y states that man does not inherently dislike work, nor does he have to be pressured to produce. Instead man seeks responsibility and can work effectively, enjoying the fruits of his efforts in his achievements.

The "integration of goals" as McGregor calls Theory Y, is based on the motivational aspects of human behavior. It leads to an employer-employee relationship which may be expressed as follows, "Between every individual and the organization for which he works is a psychological contract, defined by the expectations of the individual and of the organization. Some of these contractual expectations are very explicit, such as desired salary or required technical competence. Others are implicit such as the desire to be challenged or the expectation that the

\[\text{McGregor, Op.Cit.}\]
individual will adhere to company norms. The mutual fulfillment or non fulfillment of these expectations, whether explicit or implicit, is related to the personal adjustment and career development of the individual and to the efficient functioning of the organization."\textsuperscript{5} It is the "integration of goals" (Theory Y) which serves in this thesis as the underlying philosophy of approach to managements' control and direction over the human resources of the organization.

Systems explaining human behavior are not necessarily self-apparent. A system is a conceptual framework which is formulated by the systems analyst after observing real-world phenomenon. Once his observations have been made, it is the major problem of the analyst to select the key variables which are pertinent to the system. These variables can then be related in a complex model which provides the basis for a deeper understanding of the system. Figure 2.1 is one such model.

It represents the interaction of managements' evaluation and incentive policies with the motivation, social relations, and technical performance of the individual staff member. As this is obviously a feedback system there is no natural place to start an analysis, but by defining the various sectors in greater detail and tracing the causal links between them a better understanding of the system can be achieved.

\textsuperscript{5}David E. Berlew and Douglas Hall, "The Management of Tension". (The Industrial Management Review, Alfred P. Sloan School of Management, M.I.T., Fall 1964).
Figure 2.1 Causal Interaction Of Key System Variables
In order to clarify the analysis it might be helpful to think of this company as one engaged in research and development. Its staff members are engineers and scientists, almost all of whom possess a technical degree. This is not a production oriented company. It may develop a sophisticated piece of electronic equipment or investigate and research a technical problem and prepare a report on its findings. The sources of work come from contracts awarded to the company by a customer. The customer initiates the contract awarding process by requesting a proposal from the research and development company. These requests for proposals (R.F.P.'s) are usually received based on the company's high quality performance on past contracts. Once the request is received by the company, a staff member or group of staff members prepares a proposal. It is assumed that the customer awards the contract primarily on the basis of the technical merit of the competitors, demonstrated in part in their proposals. Bid cost and completion data are assumed to be comparable for all companies submitting a proposal to the customer, or at least the differences are not overly significant. Once a contract has been awarded, it becomes an in-house contract. The staff member responsible for the contract must allocate time and effort toward its completion.

Management evaluates the performance of the staff member on his ability to turn out high quality contract work and his ability to write and prepare successful proposals. The quality of contract work is difficult to measure. Management may view quality in one way and the
customer in quite another. The research and development company receives information feedback from the customer on the quality of work both directly through conversations and indirectly by the number of requests for proposals which the customer issues to the company. The delays in receiving this feedback are important determinants of system behavior. Proposal worth may be much simpler to evaluate because the company receives almost immediate feedback from the customer. It is quite easy to measure the number of contracts awarded in response to the number of proposals written.

The total appraisal of the engineer's competence is viewed as a weighted average of his efforts on proposals and his efforts on contracts. The weightings are determined by the backlog of contract work that the engineer must complete. For example, if an engineer has a huge backlog of contract work he will not be expected to spend time writing proposals, and his evaluation is based exclusively on his performance on contracts. On the other hand, if the engineer is not working on any of his own contracts, he may be asked to "help out" his colleagues on their contracts and spend the rest of his time writing unsolicited proposals in order to persuade the customer to initiate a contract.

The incentives a staff member receives depend quite heavily on his appraised value to the company. If the engineer receives a favorable evaluation, he is rewarded. Primarily this consists of a salary increase. However, the company management is also aware of the motivational value of promotions and recognition, and these also are
rewards. If the staff member does not meet company expectations, pressure is exerted on him to improve his performance or face possible termination. This threat to his job security is "real" if the employee wants to continue working for the company and does not seek alternative employment.

The incentives a company offers have no direct effect on a staff member's performance, but rather they effect his motivation to work. The causal link between motivation to work and performance is very complex and has been the point of many psychological studies. Motivation as used in this thesis refers to institutional motivation. "The institutionalist identifies with the organization and its goals, uses the organization as his principal career frame of reference, implies that he will remain in the organization. The non-institutionalist does not identify with the organization and its goals, does not see his career in terms of the organization, and is willing to leave the organization." 6

This thesis is concerned with an individual who wishes to remain with the organization. Motivation to work refers to the professional's desire to perform work in the interests of the research and development company. Most studies indicate that highly motivated workers are willing to work harder and longer, are more satisfied by their job, and provide greater contributions to company goals. 7 There are other studies, which indicate,

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however, that job satisfaction is uncorrelated with performance. For the purpose of this thesis a person who is highly motivated toward achieving company goals will contribute more to these goals than a person who is not so motivated; provided, of course, they have approximately the same level of competence.

In addition to the motivation to perform useful work, the model includes a sector referred to as the motivation to interact. This interaction is primarily with the other staff members and takes the form of cooperation, communication and social cohesion. The motivation to interact is partly a function of the incentive offered by the company and partly affected by the social environment itself.

The sector labelled interaction needs some clarification. It is essentially a concept referring to the friendliness and cooperativeness that exists among members of the technical staff. Low social interaction would imply that staff members do not spend much time together outside of occasions when they are required to work together. It implies cooperative efforts only when management insists, but not voluntarily on their own time. High social interaction might imply a friendly, cohesive atmosphere in which all cooperate. However, it has its disadvantages in that much time is wasted on non-company oriented activities and company time is used inefficiently.

Human behavior varies from individual to individual. Some people work more effectively and are happier when they are left to work by

\textsuperscript{8}Myers, Op.cit.
themselves. These people are not motivated by the approval or acceptance of their colleagues. For the purposes of this thesis, these individuals are pathological examples. Most people are clearly affected by the extent of interaction with the people with whom they work.

Many factors determine the performance of an individual. Some of these cannot be affected by company policy or environment, such as natural intelligence or creativeness. Others such as the motivation to work are clearly company induced. Interaction affects performance. The degree of cooperation and the flourishing of new ideas, stimulated by constant communication between engineers, are vital to the growth of a company, especially one engaged in research and development work.

The overall system just described contains many interacting feedback loops. The loop structure of the model will be analyzed more thoroughly in Chapter 4. In that chapter the behavior of the model will be examined also.

In order to handle the complexity of this system, it is necessary to program the model in a language suitable for use on a digital computer. The next chapter provides a detailed description of the way in which the variables interact along with the equations necessary for the computer. The equations are in the form of linear difference equations in the DYNAMO computer language. Background and understanding of this language can be found in Industrial Dynamics by Jay Forrester9

and the DYNAMO User's Manual by Alexander Pugh.\textsuperscript{10}

CHAPTER 3

INDUSTRIAL DYNAMICS FORMULATION OF THE MODEL

In order to facilitate understanding of the construction of the Industrial Dynamics model, Figure 2.1 is reproduced as Figure 3.1. Each of the key sectors has been numbered, and the causal linkages between them have been lettered. The rest of this chapter explains the formulation of each of these interconnections, its effect on the sector to which it provides an input, and the resulting output from this sector. Appropriate references to Figure 3.1 will be made throughout the chapter.

Motivation From Incentives

This section refers to linkage A in Figure 3.1 and relates the salary increases and promotions which the company provides, to the motivation that they develop in the professional staff member. It also relates the pressure exerted on an individual to improve his performance, if it is below company expectations, to the level of motivation provided by the pressure. Stress occurs because the individual perceives this pressure as a threat to his job security, and is motivated to improve his technical performance.

The practical logic of incentives is that people want money, position, and prestige and that they are willing to work harder to
Figure 3.1  Causal Interaction of Key System Variables-Lettered
get these inducements.\textsuperscript{1} In this sense the incentives offered by the company serve to motivate increased productivity of the employee.

The prime motivators of human behavior in any organizational setting are the economic rewards which are offered by the company in return for the employee's contributions in furthering company objectives. The salary a staff member receives plays an important role in motivating his performance. The individual is actually motivated not by his level of salary, but by the expected increase in salary he hopes to get in return for the productive and useful work which he contributes. His salary - derived motivation is determined by comparing the offered increase in salary to the salary increase he expects. Initially his expectations are based on comparative pay increases received by other individuals in the industry in his position. The model sets this initial expected increase at eighty dollars per month. As he continues his employment he compares the offered increase to the average increase he has become accustomed to receiving. Figure 3.2 illustrates the relationship between motivation to work and salary increase. A normal increase factor of 1 produces normal motivation. As the salary increment becomes larger motivation can intensify to one and a half times normal motivation. This implies that the employee puts in fifty per cent more time and effort than he ordinarily would. It is clear that if the increase does not match his expectations the employee

\textsuperscript{1}McGregor, \textit{Op.cit.}
becomes dissatisfied and his motivation to work is reduced. As an employee's level of salary grows, the effect of a wage increase on his motivation becomes less pronounced.\textsuperscript{2} To account for this, a salary multiplier is introduced. The salary multiplier plotted as a function of salary is illustrated in Figure 3.3.

\[
\begin{align*}
\text{MSI}.K &= \text{TABHL}(\text{TMSI, SIRE.K, 0, 2.5, .5}) & 1,A \\
\text{TMSI}^* &= .8/.9/1/1.2/1.4/1.5 & 1.1,C \\
\text{SIRE}.K &= \text{SI.JK/ESI.K} & 2,A \\
\text{ESI}.K &= \text{ESI.J}+(\text{DT})(1/\text{DAS})(\text{SI.JK-ESI.J}) & 3,L \\
\text{ESI} &= 80 \text{ dollars} & 3.1,N \\
\text{DAS} &= 24 \text{ months} & 3.2,C \\
\text{MS}.K &= (\text{MSI}.K)(\text{MSM}.K) & 4,A \\
\text{MSM}.K &= \text{TABHL}(\text{TSM}, S.K, 0, 30000, 10000) & 5,A \\
\text{TSM}^* &= 1/1/.95/.85 & 5.1,C \\
\end{align*}
\]

\textbf{MSI} - Motivation From Salary Increase  \\
\textbf{TMSI} - Table, Motivation From Salary Increase  \\
\textbf{SIRE} - Salary Increase Relative to Expected  \\
\textbf{ESI} - Expected Salary Increase  \\
\textbf{SI} - Salary Increase  \\
\textbf{DAS} - Delay to Assess Salary  \\
\textbf{MS} - Motivation From Salary  \\
\textbf{MSM} - Motivation From Salary, Multiplier  \\
\textbf{TSM} - Table, Motivation From Salary, Multiplier  \\
\textbf{S} - Salary

The individual is also motivated by promotions and the accompanying increase in prestige and recognition. Although higher positions tend to

\textsuperscript{2}Simon and March, \textit{Op.cit.}
be tightly correlated with increased wages, there tends to be a strong motivational factor arising from the psychological boost of higher prestige and recognition of achievement. Even at high levels of salary this psychological factor is still present. In fact, if one accepts A. H. Maslow's\(^3\) conception of the needs of individuals it follows that, at least, for professional technical people, promotions and recognition are more important motivators of performance than are wages. Maslow asserts that man's most basic need is for security. However, professional technical people are usually in high demand and can command salaries which essentially satisfy this need. Once this basic need is satisfied, higher order needs become increasingly important. These higher order needs include status, prestige, self-esteem, etc. Promotions and recognition of achievement are useful incentives in fulfilling these needs, thus providing strong motivation for the professional worker.

The formulation of the motivation from position sector of the model parallels the structure of the motivation from salary sector just described. The employee compares the promotion or position increase with what he expects. His expectations are based on his previous rate of rise in the company. Thus a fast rising employee will expect a continued quick rise and he will be dissatisfied with less. The relationship between motivation from position increase and position increase itself is plotted in Figure 3.4. The diagram indicates that if an employee is seeking a promotion he

\(^3\)A. H. Maslow, Motivation and Personality. (Harpur & Brothers, New York, 1954).
Figure 3.2 Motivation from Salary Increase

Figure 3.3 Salary Multiplier
Figure 3.4  Motivation from Position Increase
will work twice as intensely as he normally would.

\[ \text{MPI.K} = \text{TABHL(TMPT,PIRE.K,0,2.5,.5)} \]
\[ \text{TMP*} = .7/.8/1/1.5/1.8/2 \]
\[ \text{PIRF.K} = \text{PI.JK/EPI.K} \]
\[ \text{EPI.K} = \text{EPI.J+(DT)(1/DAP)(PI.JK-EPI.J)} \]
\[ \text{EPI} = 1 \]
\[ \text{DAP} = 36 \text{ months} \]

6,A
6.1,C
7,A
8.1,N
8.2,C

MPI - Motivation From Position Increase
TMP - Table, Motivation From Position Increase
PIRE - Position Increase Relative to Expected
PI - Position Increase
EPI - Expected Position Increase
DAP - Delay to Assess Position

Both salary increase and promotions are indications of a "favorable evaluation" of performance and are in a sense rewards. These rewards tend to be reinforcing and thus the model formulates reward motivation as the product of motivation from salary and motivation from position.

\[ \text{RM.K} = (\text{MS.K})(\text{MPI.K}) \]

9,A

RM - Reward Motivation
MS - Motivation From Salary
MPI - Motivation From Position Increase

If the individual's performance does not measure up to company expectations, the company can exert pressure on the employee to improve his work or to threaten him with termination. Knowledge of human behavior suggests that a man will do tremendous amounts of work beyond his normal pace when the threat is real, i.e., he wants to remain employed with the company.\(^4\) The company can exert pressure either to improve performance

on writing proposals or to improve quality of contract work or both. The extent of motivation vs. contract pressure is graphed in Figure 3.5. This functional form also holds for extent of motivation vs. proposal pressure. It is noticed that motivation can only be pushed to a certain point and that after this point, pressure has the effect of causing the individual to rebel and refuse to work. This "breaking point" is related in most cases to the number of alternatives open to the individual. For example, a man who has been floating from job to job and therefore is worried about being able to remain employed will absorb more pressure and coercion than somebody for whom it will be easy to find another job.

Pressure builds up over a two to five month period to produce a level of motivated effort. Pressure to improve proposal quality is felt more rapidly as proposal work requires at most two or three months to complete, whereas contract work proceeds at a slower pace. Initially both levels of motivation are set at an index value of \( (1) \) or normal.

\[
\begin{align*}
MPP.K &= MPP.J + (DT)(1/DMPP)(CMPP.JK-MPP.J) \\
MPP &= 1 \\
DMPP &= 2 \text{ months} \\
CMPP.KL &= \text{TABHL}(TCMPP,PPW.K,0,3,.5) \\
TCMPP* &= .5/.75/1/1.5/2/1.5/1.5 \\
\end{align*}
\]

\[10,L \quad 10.1,N \quad 10.2,C \quad 11,R \quad 11.1,C\]

- MPP - Motivation From Proposal Pressure
- DMPP - Delay to Motivate Proposal Pressure
- CMPP - Change in Motivation From Proposal Pressure
- TCMPP - Table, Change in Motivation From Proposal Pressure
- PPW - Pressure to do Proposal Work

\[5 \text{Simon and March, Op.Cit.}\]
Figure 3.5 Motivation From Pressure
MCP.K = MCP.J + (DT)(1/DMCP)(CMCP.JK-MCP.J)  
MCP = 1  
DMCP = 5 months  
CMCP.KL = TABHL(TCMCP,PCW.K,0,3,.5)  
TCMCP* = .5/.75/1/1.5/2/1.5/.5  
MCP - Motivation From Contract Pressure  
DMCP - Delay to Motivate Contract Pressure  
CMCP - Change in Motivation From Contract Pressure  
TCMCP - Table, Change in Motivation From Contract Pressure  
PCW - Pressure to do Contract Work

Motivation From Social Interaction

In addition to the explicit motivation which the company provides by its incentives, an employee is motivated by the groups and individuals with whom he associates. Professional employees are continually called upon to work in groups, usually called project teams. The cohesiveness of the group and the social atmosphere which exists within the company are basic in determining the motivational drives of a professional staff member. Maslow refers to the associations a person forms with his colleagues as satisfying his need to belong\(^6\), to be a part of the organization. When these needs are satisfied, an individual is not only happier, he is more highly motivated to contribute to the organization. An individual working in a cohesive, friendly atmosphere will be stimulated to perform his tasks willingly and efficiently.\(^7\)


A group which is cohesive is one in which the individuals in the group are all working to secure the goals for which the group was organized. They are not, instead, trying to satisfy their own personal desires. Cohesion implies cooperation, rather than competition. Group cohesion is plotted on a scale from zero to two. Zero would represent no cohesion at all, and two represents twice normal cohesion. Normal cohesion is set at an index value of (1) and it is assumed that it has no effect on an individual's behavior. He is neither highly motivated nor highly un-motivated.

As group cohesion varies it also changes an individual's motivation developed from this group cohesion. This level of motivation is formulated by averaging the effects of group cohesion over a two month period of time. Figure 3.6 relates changes in motivation to group cohesion. The curve indicates that the level of motivation can vary from half normal motivation to twice normal motivation.

\[ MGC.K = MGC.J + (DT)(1/DMGC)(CMGC.JK-MGC.J) \]

- **MGC** - Motivation From Group Cohesion
- **CMGC** - Change in Motivation From Group Cohesion
- **TCMG** - Table, Change in Motivation From Group Cohesion
- **DMGC** - Delay in Motivation Change From Group Cohesion
- **GC** - Group Cohesion
Figure 3.6 Motivation from Group Cohesion
The extent to which an individual needs to belong varies from one person to another. Some people work well by themselves. Others are so strongly influenced by their relationships with others that they will sacrifice salary raises and promotions in order to gain approval from their colleagues. It is hard to differentiate between different behavioral characteristics. The model cannot do so. The characteristics attributed to the staff member represented in the model are based on statistical findings on the behavior of so-called normal or average human beings.

This sector is concerned with linkage B in Figure 3.1 and relates the cohesiveness of the groups within the professional organization to the motivation which the engineer develops from being a part of the organization.

Motivation Effects on Technical Performance

This section refers to linkage C on Figure 3.1. It provides a framework with which the levels of individual motivation described in the previous sections are related to the division of a professional technical person's energies between performing contract work and proposal work.

Each staff member must allocate a certain amount of time to writing proposals and to working on contracts that his firm has already been awarded. In most situations this allocation is determined by company

---

by company management. If there is an overload of "in-house" contract work, the employee is required to work on contracts. On the other hand, a slack period forces the engineer to become a salesman and to solicit more business. Even though the allocation of time is made for him, the individual still determines the intensity of his work and the number of hours he puts in. These are controlled by the levels of motivation just formulated. In professional organizations, the eight or nine to five day is not sacred. A professional may find himself taking his work home with him every night. In terms of time, he may actually be working as much as eighty hours a week and not forty. The nature of the incentives which the engineer receives, determines, in part, how he allocates his energies between contract work and proposal work.

If the engineer is doing poorly, i.e., his evaluation is low, then he reacts to the pressures for improved performance which are exerted on him. An employee who is not meeting management's expectations is informed where his deficiencies lie and he adjusts his efforts to try and remove these deficiencies. Thus, in the model if the engineer's evaluation is more than ten per cent below normal the determinants of his motivational levels are company pressure to do proposal work and company pressure to do contract work. In this sense the engineer who is under stress is almost completely guided by management. His decisions as to the division of his energies are made for him.
A completely different situation occurs, however, when the engineer is doing well. Usually an engineer who receives a high evaluation is not told specifically how to allocate his energies. A word of encouragement, a wage increase, and perhaps a promotion all serve as indicators of management's pleasure at his performance, but they do not provide any guidance for the individual's efforts. Knowledge of human behavior indicates that if a person has received a favorable reaction to his efforts, he will try to maintain the status quo, that is he will not make any adjustments or changes in his behavior. Thus in this case model provides for only very slow changes in the staff member's behavior. These changes are caused by the individual's perception of the standards by which he is being evaluated. For example, if he feels the company is stressing quality of contract work, as reflected in its evaluation of the employees, he will be more motivated to work on contracts.

In a sense, it is the engineer's perception of company goals and interests that determines the extent of his efforts on proposal and contract work. In the situation of poor performance these goals are specifically made clear. In the situation of high performance, these goals and interests remain somewhat hidden and ambiguous. Initially the engineer's perceptions of the standards the company is using to evaluate its employees is accurate, as he has been told these standards when he joined the organization. In the case of an evaluation which is neither highly favorable nor highly unfavorable, the engineer is motivated by a mixture of rewards and pressures.

---

MIC.K = MIC.J+(DT)(1/DIMC)(CMIC.JK-MIC.J) 16,L
MIC = CMIC 16.1,N
DIMC = 2 months 16.2,C
CMIC.KL = (REM.K)(MRIC.K)+(PEM.K)(MCP.K) 17,R
MRIC.K = (FMIC.K)(RM.K) 18,A
REM.K + TADM(TREM,CE.K,.9,1.1,1) 19,A
TREM* = 0/.5/1 19.1,C
PEM.K = 1-REM.K 27,A
FMIC.K = TABHL(TFMIC,CWFO.K,.9,1,.5) 20,A
TFMIC* = .5/1/2 20.1,C
CWFO.K = CWFO.J+(DT)(1/DOWF)(CWF.J-CWFO.J) 21,L
CWF = CWFO 21.1,N
DOWF = 24 months 21.2,C

MIC - Motivation From Incentives, Contract Work
CMIC - Change in Motivation From Incentives, Contract Work
DIMC - Delay to Induce Motivation Change
MRIC - Motivation From Reward Incentives, Contract Work
TREM - Table, Reward Effect on Motivation
REM - Reward Effect on Motivation
FMIC - Fraction of Motivation From Incentives, Contract Work
TFMIC - Table, Fraction of Motivation From Incentives
CWFO - Contract Weighting Factor Observed
CWF - Contract Weighting Factor
DOWF - Delay to Observe Weighting Factor
PEM - Pressure Effect on Motivation
CE - Company Evaluation
MCP - Motivation From Contract Pressure
RM - Reward Motivation

(There are an identical set of equations which relate the levels of motivation to work, to the engineer's efforts on proposed preparation. They are not included here, but can be found in the Appendix.)
In addition to motivation directly induced by company policy, the engineer's level of motivation is determined by group cohesiveness. In most situations contract work requires the group efforts of many people working together, whereas many proposals are written individually, with perhaps the advice or assistance of only a limited number of other staff members. To account for this, the effect of group cohesion on contract work is weighted three times more heavily than its corresponding effect on proposed work.

\[
MFGC.K = (MCON)(MGC.K) \quad 22,A
\]

\[
MCON = .75 \quad 22.1,C
\]

\[
MFGP.K = (MPRO)(MGC.K) \quad 30,A
\]

\[
MPRO = 1-MCON \quad 30.1,N
\]

- **MFGC** - Motivation From Group, Contract Work
- **MCON** - Constant, Contract Motivation
- **MFGP** - Motivation From Group, Proposal Work
- **MPRO** - Constant, Proposed Motivation
- **MGC** - Motivation From Group Cohesion

Total motivation to do contract work on proposal work is formulated as the sum of company induced motivation and motivation from group cohesion.

\[
MCW.K = MIC.K+MFGC.K \quad 23,A
\]

\[
NMCW = MCW \quad 23.1,N
\]

\[
MPW.K = MIP.K+MFGP.K \quad 31,A
\]

\[
NMPW = MPW \quad 31.1,N
\]
MCW  - Motivation to do Contract Work
NMCW - Normal Motivation to do Contract Work
MIC  - Motivation From Incentives, Contract Work
MFGC - Motivation From Group, Contract Work
MPW  - Motivation to do Proposal Work
MIP  - Motivation From Incentives, Proposal Work
MFGP - Motivation From Group, Proposal Work
NMPW - Normal Motivation to do Proposal Work

Motivation to Interact

The intended purpose of the incentives offered by a company is to motivate the employee toward greater technical performance. Often overlooked, however, are the unintended implications of these incentives on the individual's desire to interact with others in the organization.

An engineer who has not met the organization's expectations is put under pressure to improve his performance. His motivation to interact decreases, because he is insecure about his job and can afford less time to socialize and interact with fellow employees. The greater the threat to his job security, the less time he has to interact with other staff members, unless it is essential to the tasks he is performing.

Figure 3.7 illustrates the relationship between the effect of proposal pressure on interaction and motivated proposal pressure. The functional dependence of contract pressure effect on interaction on motivated contract pressure is modelled in identical form. The model formulates pressure effect on interaction as a percentage change in the level of motivation to interact. Obviously this is a negative percentage change, as pressure causes a decrease in this motivation level. In the model strong pressure produces as much as a thirty per cent decrease in the
Figure 3.7 Effect of Pressure on Interaction
motivation to interact over a two month period of time. (This type of quantitative assumption can neither be validated nor discounted on the base of available data. Quantitative descriptions of intangibles cannot be avoided by the model builder. He can only conclude after simulating the model on a computer and observing the effect of varying this kind of parameter, whether or not it has an important effect on system behavior. If it does, experimental data must be gathered before a reliable model can be constructed. If it does not, intuition is as good a criterion as anything else.)

\[
\begin{align*}
\text{EPPI.K} &= \text{TABHL(TEPPI,MPP.K,1,2,2)} & 32,A \\
\text{TEPPI*} &= 0/-0.02/-0.06/-1/-2/-3 & 32.1,C \\
\text{ECPI.K} &= \text{TABHL(TECPI,MCP.K,1,2,2)} & 33,A \\
\text{TECPI*} &= 0/-0.02/-0.06/-1/-2/-3 & 33.1,A \\
\text{PEI.K} &= (\text{MI.K})(\text{EPPI,K+ECPI.K}) & 34,A \\
\end{align*}
\]

\begin{align*}
\text{EPPI} &- \text{Effect of Proposal Pressure on Interaction} \\
\text{TEPPI} &- \text{Table, Effect of Proposal Pressure on Interaction} \\
\text{MPP} &- \text{Motivation From Proposal Pressure} \\
\text{ECPI} &- \text{Effect of Contract Pressure on Interaction} \\
\text{TECPI} &- \text{Table, Effect of Contract Pressure on Interaction} \\
\text{MCP} &- \text{Motivation From Contract Pressure} \\
\text{PEI} &- \text{Pressure Effect on Interaction} \\
\text{MI} &- \text{Motivation to Interact}
\end{align*}

The effect of a reward, in the form of a salary increase or promotion, on a professional employee's motivation to interact is probably a very complicated function of the individual's personality and the relationships he has formed with his colleagues. In order to simplify the problem of quantizing this effect the following analysis is presented.
A reward is usually interpreted by an individual as signifying that his actions have pleased the person or organization awarding the reward. In this sense, rewards serve as amplifiers, amplifying the actions of the rewarded individual. For example, a baseball player who receives a bonus for hitting a home run will try even harder to hit a home run the next time at bat. A professional staff member who is highly cooperative will perceive a reward from management as being partly a result of his cooperative efforts. This will motivate him to cooperate and interact to even a greater degree. On the other hand, an individual who works mainly by himself and does not cooperate will perceive a reward as partly due to his individualism and will be motivated to work even more independently.

The engineer essentially correlates the rewards he receives with the social situation as he perceives it. If group cohesion, as the individual perceives it, is below normal, a reward tends to drive him further away from his colleagues. This is illustrated in Figure 3.8. The reward might make the individual more self-reliant and give him increased self-confidence. It may also, in an atmosphere of low cohesion, produce an undertone of resentment and jealousy in the other staff members. If the professional feels group cohesion is high, he believes his interaction may be partly responsible for the reward. His response to a reward is to desire to maintain a high level of interaction without making too much of a change in his behavior patterns. Refer to Figure 3.9 for the functional relationship between these variables.
The formulation of the reward effect on interaction is the same as the formulation for the effect of pressure on interaction, i.e., it produces a percentage change in the level of motivation to interact. Notice that in the case of reward incentives, these percentage changes are not as great as the changes produced by pressure exerted on the individual. Again this is to take into account knowledge of human behavior which suggests that rewarded individuals tend to amplify their actions without appreciably altering the status quo.

\[
\begin{align*}
RCC_K &= \text{CLIP}(ERWC_K, ERNC_K, MGC_K, .99) \\
ERNC_K &= \text{TABHL}(TERNC, RM_K, 1, 2, .2) \\
TERNC^* &= 0/- .01/- .02/- .05/- .07/- .1 \\
ERWC_K &= \text{TABHL}(TERNC, RM_K, 1, 2, .2) \\
TERWC_K &= 0/.01/.02/.02/.02/.02 \\
REI_K &= (RCC_K)(MI_K)
\end{align*}
\]

RCC - Reward, Cohesion, Correlation  
ERNC - Effect of Reward, no Cohesion  
TERNC - Table, Effect of Reward, no Cohesion  
ERWC - Effect of Reward, with Cohesion  
TERWC - Table, Effect of Reward, with Cohesion  
MGC - Motivation from Group Cohesion  
RM - Reward Motivation  
REI - Reward Effect of Interaction  
MI - Motivation to Interact

Another determinant of an individual's motivation to interact is the cohesiveness of the group itself. As many authors have pointed out, the need of a person to mix with a group, to feel a member of the organization, is very basic. If cohesion is high and the individuals
Figure 3.8  Reward Effect on Interaction-No Cooperation

Figure 3.9  Reward Effect on Interaction-With Cooperation
are working in a friendly, casual atmosphere, they will attempt consciously or sub-consciously to retain this atmosphere.\textsuperscript{10} If cohesion is low, however, a person tends to move further away from the group, preferring to establish associations and friendships outside the group. He tends to identify with these outside interests rather than with the non-cohesive groups.\textsuperscript{11} His motivation to interact with these groups decreases. Again the formulation is in terms of the effect of group cohesion causing a percentage change in the motivation to interact. Figure 3.10 graphically depicts these percentage changes.

\[
\begin{align*}
\text{EGC} \cdot K &= \text{TABHL(TEGC, GC} \cdot K, 0, 2, .5) \\
\text{TEGC}^* &= -.04/-0.02/0/.01/02 \\
\text{CEI} \cdot K &= (\text{EGC} \cdot K)(\text{MI} \cdot K)
\end{align*}
\]

\begin{itemize}
\item EGC - Effect of Group Cohesion
\item TEGC - Table, Effect of Group Cohesion
\item GC - Group Cohesion
\item CEI - Cohesion Effect on Interaction
\item MI - Motivation to Interact
\end{itemize}

Overall changes in the level of motivation to interact are produced by the sum of the effects of the three variables, pressure, reward and cohesion. Initially, this level of motivation is set at an index value of 1, representing normal motivation. It then varies as a two month average of these changes just described.


Figure 3.10 Effect of Group Cohesion on Interaction
MI*K = MI*J+(DT)(1/DIM)(CMI*JK+O)

MI = MII

MII = 1

DIM = 2 months

CMI*KL = PEI.K+REI.K+CEI.K

MI - Motivation to Interact
MII - Initial, Motivation to Interact
DIM - Delay to Induce Motivation
CMI - Change in Motivation to Interact
PEI - Pressure Effect on Interaction
REI - Reward Effect on Interaction
CEI - Cohesion Effect on Interaction

The concepts described in this section are well known to sociologists and psychologists. However, management tends to associate incentives only with performance and not with interaction. Although the resulting implications on an individual's desire to interact may be of little consequence in a production-oriented company, these consequences may be far more apparent in a firm in the knowledge industry. This last section refers to linkage D in Figure 3.1. It relates to an important and often unnoticed effect of incentives; namely, the effect on the desire of an individual to interact within the group structure of the organization.

Social Interaction

The extent to which a professional technical employee interacts with other technical people is determined by his own personal needs for interaction, the particular demands of his job, and the physical environment in which he works. For example, a staff member who spends most of his time traveling and visiting customers does not have the opportunity to
interact with other company staff members as does a staff member who is stationed permanently at the main office. Nor does an employee who is physically isolated, by means of the location of his office, have as much opportunity to interact as does an employee more centrally located. However, these considerations are beyond the scope of this thesis.

Clearly social interaction depends heavily on the nature of the individuals who comprise the staff. In order to avoid explicitly assigning behavioral characteristics to each individual, this thesis defines the group as a passive entity which has no direct influence on an individual staff member. The extent of interaction in which any one employee engages is determined solely by his own motivation to interact and not by the reaction of the group. Social interaction is treated as a level. Changes in this level are produced by changes in the individual's motivation to interact. These changes are formulated as percent changes of the level. These changes are plotted in Figure 3.11. The level of social interaction can assume any value on a scale from 0 to 10. A value of 0 on this scale represents little or no social interaction. The individual works entirely by himself and does not communicate with the other employees outside of strictly technical or task - oriented conversations. A value of 10 on this scale would imply constant interaction, very little individual work, and most of the time spent on non-task - oriented activities. Social interaction is initially set at a scale value of 5. This represents as will be explained later the maximum interaction without any wasted effort.
Figure 3.11 Changes in Social Interaction
\[ \text{SIN}_K = \text{SIN}_J + (\text{DT})(\text{CSIN} \cdot \text{JK} + 0) \]

\[ \text{SIN} = \text{SINI} \]

\[ \text{SINI} = 5 \]

\[ \text{CSIN} \cdot \text{KL} = (\text{PCSIN} \cdot \text{K})(\text{SIN} \cdot \text{K}) \]

\[ \text{PCSIN} \cdot \text{K} = \text{TABHL}(\text{TPSIN} \cdot \text{M} \cdot \text{K}, 0, 2, .5) \]

\[ \text{TPSIN}^* = -.2/-1.05/.1 \]

Social interaction is a key variable in this system model. The level of social interaction determines three important parameters.

1. As social interaction increases so does group cohesion. The more time individuals in a group spend together, the closer becomes the bond between them.\(^{12}\) Group cohesion is, essentially, a measure of cooperation. A highly cohesive group, works together toward achieving the objectives for which it was organized. The individuals who comprise the group are willing to cooperate voluntarily. Smoother cooperation enables those in a cohesive group to perform their tasks more efficiently than those in a non-cohesive group.\(^{13}\)


In the absence of social cohesion, competitive striving for an outstanding performance record develops. The individuals compete against one another and often are unwilling to cooperate. When cooperation is necessary it is not as smooth as is the cooperation of individuals in a cohesive group. Figure 3.12 suggests the relationship between group cohesion and social interaction.

\[
GC.K = \text{TABHL(TGC, SIN.K, 0,10,2)}
\]

\[
\text{TGC} = 0/.5/.75/1.25/1.75/2
\]

\[47,A\]

\[47.1,C\]

- GC - Group Cohesion
- TGC - Table, Group Cohesion
- SIN - Social Interaction

2.) The extent of social interaction is closely related to the degree to which staff members talk to one another. The flow of ideas and the communication of information is invaluable to a technical organization, especially in the knowledge industry where ideas and concepts change so rapidly. Professional technical people are constantly exchanging ideas, whether it be at lunch or on the golf course. Clearly the more these people interact, the more they communicate. Figure 3.13 which relates, graphically, communication to interaction has the same functional form as Figure 3.12.

(Again these relationships appear intuitively reasonable and no data exists which might provide a more firm foundation on which to base them.)

Figure 3.12 Group Cohesion

Figure 3.13 Communication
3.) It might appear from the previous sections that it is advantageous to have as much social interaction in a research firm as is possible. This would be true except for the third parameter which is highly correlated with social interaction; namely, efficient use of time. As interaction increases less time is spent on technical matters. Much of this type of interaction is concerned with activities which are not related to the business organization, eg., hobbies, social life, etc. The best term to describe this interaction is "goofing off." Goofing off is as much a part of interaction as is group cohesion and communication. As social interaction increases all three increase. Goofing off is measured in the model by the term, efficient use of time. A person who uses all his time efficiently is not goofing off. As interaction increases the efficient use of time decreases until only 10 per cent of the available working hours are devoted to business activities. Figure 3.14 illustrates the functional relationship.

\[
\begin{align*}
C_{KL} &= \text{TABHL}(TC, SIN.K, 0, 10, 2) \quad 46, R \\
TC^* &= 0/.75/1.25/1.75/2 \quad 46.1, C
\end{align*}
\]

\[
\begin{align*}
C &= \text{Communication} \\
TC &= \text{Table, Communication} \\
SIN &= \text{Social Interaction}
\end{align*}
\]

\[
\begin{align*}
EUT.K &= \text{TABHL}(TEUT, SIN.K, 5, 10, 1) \quad 49, A \\
TEUT^* &= 1/.9/.7/8.5/.3/.1 \quad 49.1, C
\end{align*}
\]

\[
\begin{align*}
EUT &= \text{Efficient Use of Time} \\
TEUT &= \text{Table, Efficient Use of Time}
\end{align*}
\]
Figure 3.14 Efficient Use of Time
Figure 3.14 Efficient Use of Time
Essentially linkage F in Figure 3.1 connects the personal motivation of a professional technical person to interact, with the effect of this interaction on the efficiency of the group structure of the research and development organization. Hidden in this connection lies a major assumption of the model. It attributes characteristics to a collection of professional people by observing the behavior of an average individual selected from the group. It assumes that if this one individual wants to cooperate and communicate, the other individuals in the group will feel the same inclination. At least, they won't prevent him from doing so. The assumption is justified if all the members of the technical staff are motivated toward the same goals and have the same needs.

Quality of Contract Work

Up until now the model description has tended to deal with two separate features of a professional. One is the individual motivation of the professional staff member to do useful company work. The other is the cohesiveness of the groups with which the individual works. These two features are related in that both are important factors in determining the quality of contract work which the individual produces. In some cases, an engineer works by himself on his contracts. Most times, however, he works in a project team. The coordinated efforts of many staff members in required to complete these.

Quality is an intangible concept and usually depends on what aspects of the contract are important. Meeting customer specifications,
not over-running fixed costs and schedules, and providing reliable servicing are three possible aspects of a contract on which the customer may base his judgment of the quality of work. The model assumes that quality can be measured by the extent of time and effort devoted to the project, the capability of the engineers responsible for its completion, and the efficiency with which the project team operates. Quality is formulated on a scale from 0 to 2, with a scale rating of 1 representing "normal" quality. Normal, refers to industry standards which are assumed to be known. An individual's quality is treated as a weighted average of the personal performance of the staff member and the efficiency with which he coordinates his efforts with his colleagues as measured by group cohesion. This average is biased slightly toward the personal performance in order to account for the high degree of individual effort required in a research organization.

\[
QCW.K = (CTP)(TPC.K)+(CGE)(GEC.K) \\
CGE = 1-CTP \\
CTP = .6
\]

48,A
48.1,C
48.2,C

QCW - Quality of Contract Work
CTP - Constant, Technical Performance
CGE - Constant, Group Efficiency
TPC - Technical Performance on Contracts
GEC - Group Efficiency on Contracts

The individual's technical performance on contracts depends on his personal technical experience and competence, his motivation to do contract work, and his efficient use of time. The technical experience and competence of an engineer is treated as an exogenous input to the system. This input will be discussed in a later section. The incentives offered
by the company can effect a professional person's motivation to work, but it does not change his natural intelligence or inventiveness. These are characteristics which the individual brings with him to the firm and they can be amplified or blunted by the atmosphere and environment which the company helps create. Technical performance also depends on the efficiency with which the engineer utilizes his time. The most creative and highly motivated individual cannot be productive if he does not devote time and effort to a task. Brilliant individuals often never achieve full recognition because they spend so much time pursuing non-task oriented activities.

\[ TPC.K = \frac{(EUT.K)(TEC.K)(MCW.K)}{(1)(1)(NM CW)} \]

TPC - Technical Performance on Contracts  
EUT - Efficient Use of Time  
TEC - Technical Experience and Competence  
MCW - Motivation to do Contract Work  
NM CW - Normal Motivation to do Contract Work  

The group efficiency factor relates to the higher productivity of a cohesive group. The increased efficiency results in better quality work, often at lower costs. Group efficiency on contracts is treated as a level. The level is simply a smoothed average of group cohesion over a two month period. Initially the group efficiency on contracts is set equal to group cohesion.

\[ GEC.K = GEC.J+(DT)(1/DEG)(GC.J-GEC.J) \]

GEC = GC  
DEG = 2 months

54,L  
54.1,N  
54.2,C
GBC - Group Efficiency on Contracts
DEG - Delay for Effort of Group
GC - Group Cohesion

This section refers to linkages C and G in Figure 3.1 of the model and unites two important characteristics of a professional employee, namely his individual motivation toward achieving objectives and the strength of his cohesive ties to the other members of the professional technical staff. It sets up a measure of a weighted average of these characteristics and defines it to represent the quality of work produced by the professional employee.

Quality of Proposal

In this section another measure of professional performance is established; proposal worth. It too depends on the personal performance of the individual and the extent to which he interacts with other staff members. The proposal is a statement of company qualifications and it also outlines a method of approach. Its purpose is to convince the customer to release the contract to the firm which has submitted this proposal. The customer evaluates all the proposals it receives as to their technical merit and decides to which firm it will award the contract. The technical merit of the proposal depends on the technical performances of the individual's preparing it and on the degree to which the company has kept pace with the rapid changes in technology.

Technical performance on proposals relates to the intensity of effort which the professional technical employee devotes to proposal writing. It is formulated in the model as the product of his motivation to do
proposal work and the efficiency with which he utilizes his time.

$$TPP.K = \frac{(MPW.K)(EUT.K)}{NMPW}$$

TPP - Technical Performance on Proposals
MPW - Motivation to do Proposal Work
EUT - Efficient Use of Time
NMPW - Normal Motivation to do Proposal Work

It should be noted that many scientists and engineers possess a strong "non-institutional motivation"\textsuperscript{15} to work on technical projects rather than write proposals or do paper work. This is a motivation which is not a function of any company policy or decision, but a motivation derived from a love of scientific research. To these technical people, proposal writing is a source of annoyance although they realize its necessity. The model does not include this non-institutional motivation.

Besides individual technical performance, proposal worth depends on the degree to which the company keeps pace with "the state of the art." In a sense this is a measure of the flow of new ideas within the technical staff. An individual staff member cannot keep up with the quantity of scientific material published every year even in his own field. He must rely on assembling this information from other professional people, especially the ones with which he works. In order to do this, he must communicate with them. The more interaction between technical people, the greater the exchange of technical information. This exchange is an essential mechanism for keeping up with "the state of the art."

\textsuperscript{15} Refer to Page 22 of this thesis.
The model formulates this idea as a level of available technical knowledge which is an average of the rate of communication over a nine month period of time. Essentially it measures an individual's knowledge gathered from his associations with other technical people.

\[ \text{ATK}_K = \text{ATK}_J + (\text{DT})(1/DUI)(\text{CJK-ATK}_J) \]

\[ \text{ATK} = \text{C} \]

\[ \text{DUI} = 9 \text{ months} \]

ATK - Available Technical Knowledge
DUI - Delay to Utilize Information
C - Communication

These two aspects of the performance of a professional employee are averaged to attain a measure of proposal worth.

\[ \text{PW}_K = (\text{KNOWL})(\text{ATK}_K)+(\text{EXP})(\text{TPP}_K) \]

\[ \text{KNOWL} = .2 \]

\[ \text{EXP} = 1-\text{KNOWL} \]

PW - Proposal Worth
KNOWL - Constant, Technical Knowledge
EXP - Constant, Technical Experience
TPP - Technical Performance on Proposals

Proposal worth is an important criterion on which to evaluate a professional employee's performance because it is the proposal which many times makes the difference between being awarded a contract or not. The proposal is a direct attempt at soliciting business. It should present an accurate portrayal of the capabilities of the staff.
Contract Awarding Process

In the past two sections certain standards of professional performance have been established; quality of contract work, and proposal worth. The reason these two standards are important is that they are the same standards by which a potential customer, such as a government contracting agency, evaluates a research and development organization. As was stated in the opening chapter of this thesis, the professional staff member often represents the company in its customer transactions. In this sense, the customer is evaluating the individual staff members who comprise the organization as well as the organization itself.

The model assumes that the potential customers have available ten contracts per month which the staff member is technically qualified to handle. The customer initiates the award process by requesting a proposal. The request for proposal, commonly referred to as an R.F.P., implies that the contracting agency is considering the company as a possible processor of the contract. The fraction of requests which finally get forwarded to this staff member depends primarily upon his past quality of contract work. Figure 3.15 depicts the relationship graphically. Average past quality of contract work is formulated as an average of actual quality work smoothed over three years. Initially average past quality is set equal to actual quality.

\[ AC = 10 \text{ contracts} \]

\[ FRR.K = \text{TABHL}(\text{TFRR}, \text{APQCW.K}, 0, 2, 0.5) \]


\[TFRR^* = .05/.08/.2/.28/.3\] 58.1,C

\[APQCW.K = APQCW.J + (DT)(1/DOQ)(QCW.J - APQCW.J)\] 59,L

\[APQCW = QCW\] 59.1,N

\[DOQ = 36 \text{ months}\] 59.2,C

\[PRR.K = (AC)(FRR.K)\] 60,A

AC - Available Contracts
FRR - Fraction of Requests Received
TFRR - Table, Fraction of Requests Received
APQCW - Average Past Quality of Contract Work
DCW - Quality of Contract Work
DOQ - Delay to Observe Quality.
PRR - Proposal Requests Received

The model assumes that all the R.F.P.'s are answered although in actual practice this is not the case. Many times a company will not bid on a contract because it may feel that it has no chance of winning the contract, or it does not have the resources on hand to process it, etc. Usually a proposal requires about one month to prepare and write. It is then sent to the customer for evaluation. The model assumes the entire delay to complete this process is a three month period. The fraction of the proposals on which the customer awards contracts to this firm depends only on the worth of the proposal. Considerations of bid price and estimated time of completion are assumed to be comparable for all companies submitting a proposal. Figure 3.16 depicts a functional relationship between proposal worth and fraction of contracts awarded.

Once the contract is awarded, it is referred to as an in-house contract. To be realistic each of these contracts would be unique. Each would require a certain expenditure of time and effort to complete. The model assumes,
however, that all contracts are of equal difficulty and take one-man-
year of effort to complete. Once the contract is completed it is
shipped to the customer and is removed from the list of in-house
contracts. Initially the employee has a two year backlog of work,
but this level is artificially high because the contract awarding rate
is low enough so as to deplete this backlog in the first one or two
years of employment.

\[
PRA_{.KL} = \frac{PRR_{.JK}}{DCP} \\
DCP = 3 \text{ months} \\
FCA_{.K} = TABHL(TFCA_{.P}, PW_{.K}, 0, 2, .5) \\
TFCA^* = .05/.08/.2/.26/.3 \\
CIH_{.K} = CIH_{.J} + (DT)(CCIH_{.JK}) \\
CIH = CIHI \\
CIHI = 2 \text{ contracts} \\
CCIH_{.KL} = CA_{.JK} - CW\_C_{.JK} \\
CA_{.KL} = (PRA_{.JK})(FCA_{.K}) \\
CWC_{.KL} = CIH_{.K}/DCC \\
DCC = 12 \text{ months}
\]

PRA - Proposal Requests Answered
DCP - Delay to Complete Proposals
PRR - Proposal Requests Received
FCA - Fraction of Contracts Awarded
TFCA - Table, Fraction of Contracts Awarded
PW - Proposal Worth
CIH - Contracts in House
CIHI - Initial, Contracts in House
CCIH - Change in Contracts in House
CA - Contracts Awarded
CWC - Contract Work Completed
DCC - Delay to Complete Contracts
Figures 3.15 and 3.16 Contract Award Process
This section which describes linkages H, I, J, and K on Figure 3.1 relates the professional performance of an individual staff member to the contract awarding process, which is an inherent part of the research and development industry.

Company Evaluation

The previous section explored how the industry evaluates the professional performance of a staff member. Company management also evaluates him. Evaluation programs usually have two parts. The first is performance appraisal, which furnishes information for administrative decisions on promotions, salary adjustments, etc. The second part is performance review. This is designed to provide the employee himself with an evaluation of his work for self-improvement purposes.\(^{16}\) The process can be highly organized and rigid, or it can simply be the subjective opinion of the employer's immediate supervisor.

Evaluation is a comparative process, where the staff member's observed performance is compared to company expectations or norms. These norms are established as a result of the goals set by the company. For example, if a research and development company would like to maintain a certain rate of growth in terms of dollar volume of business per year, it must adjust the standards of performance it expects from its employees until it meets these goals. The model assumes these goals have been determined and that to achieve them, an employee must be able

to successfully secure 20 per cent of the contracts on which he writes a proposal and must rate an index value of 1 or normal on a quality scale. Of course, a new employee is not as experienced as one who has been with the firm many years and the company cannot expect the same standards of performance.

There are many different kinds of evaluation policies. In one the company sets a standard of performance based on the salary the employee is commanding. An employee making more money than another must contribute more to the organization otherwise he is not living up to the "psychological contract." In another policy, company norms are rigid and the employee must adjust to meet them. Finally in a third type of evaluation policy the company adjusts its expectations to the observed performance of the individual. In this way the company seeks to reduce the state of disequilibrium which results when company expectations are not met by employee contributions. The initial model employs this last evaluation procedure.

In order to attain an employee rating of quality, the company computes a level of observed quality of contract work. This rating may be the subjective opinion of the professional's immediate supervisor, or it may be an elaborate "merit rating system." In order to account for the difficulties inherent in evaluating an intangible concept such as quality, observed quality is formulated as a six month smoothed average of actual

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17 Refer to Page 17 of this thesis.

18 Refer to Page 17 of this thesis.
quality. Initially observed quality is set equal to actual quality. Once this rating of observed quality has been attained the company decides what increase in quality is expected of the individual. Figure 3.17 illustrates this relationship. The increase is then averaged over eight months in order to allow the employee time to improve his performance. The company continually compares his observed quality of work with their expectations. In this way it obtains a measure of the disparity between employee contributions and company expectations. If the comparison equals 1, the employee has met company expectations. If it less than 1, he has not met expectations. And if it is greater, he has exceeded these expectations.

\[
ECW.K = OQW.K/DQW.K \\
OQW.K = OQW.J + (DT)(1/DOQU)(QCW.J - OQW.J) \\
OQW = QCW \\
DOQU = 6 \text{ months} \\
DQW.K = DQW.J + (DT)(1/DQD)(IQD.J - DQW.J) \\
DQW = IQD \\
DQD = 8 \text{ months} \\
IQD.K = \text{TABHL(TIQD, OQW.K, 0, 2,.5)} \\
TIQD* = .5/ .75/ 1/ 1.25/ 1.5
\]

ECW - Evaluated Contract Work  
OQW - Observed Quality of Work  
DQW - Desired Quality of Work  
QCW - Quality of Contract Work  
DOQU - Delay to Observe Quality  
DQD - Delay to Attain Quality Desired  
IQD - Increase in Quality Desired  
TIQD - Table, Increase in Quality Desired
Figure 3.17  Increase of Quality Contract Work, Desired
In order to measure the staff member's performance on proposal writing, the company does not have to resort to any elaborate rating scheme. In this simple model all it need do is calculate the fraction of contracts awarded, i.e., the ratio of contracts secured to proposals written. On the basis of this fraction it decides on a desired increase. It expects the employee to meet this increase after approximately twelve months. See Figure 3.18. As in the formulation of the quality equations, the company compares the actual fraction to the desired fraction in order to obtain a measure of the disparity between company expectations and individual contributions.

\[
\begin{align*}
EPW.K &= \frac{FCA.K}{FCD.K} \\
FCD.K &= FCD.J+(DT)(1/DCD)(IFCD.J-FCD.J) \\
FCD &= IFCD \\
DCD &= 12 \text{ months} \\
IFCD.K &= \text{TABHL}(TIFCD,FCA.K,0,.3,.1) \\
TIFCD* &= .05/.15/.2/.25
\end{align*}
\]

\[71,A\]
\[72,L\]
\[72.1,N\]
\[72.2,C\]
\[73,A\]
\[73.1,C\]

EPW - Evaluated Proposal Worth  
FCA - Fraction of Contracts Awarded  
FCD - Fraction of Contracts Desired  
IFCD - Increase in Fraction of Contracts Desired  
TIFCD - Table, Increase in Fraction of Contracts Desired  
DCD - Delay to Increase Contracts Desired

Once the company has evaluated the engineer on his quality of contract work and his success in proposal writing, it obtains an overall evaluation by computing a weighted sum of these two components. The weightings are determined by two factors. First, these weights depend on the
Figure 3.18 Increase in Fraction Of Contracts Awarded, Desired
backlog of contract work which the employee must complete. Clearly, if he has a huge backlog, he cannot be expected to also write proposals. In this case, he is evaluated only on his contract work. Second, the weights depend on management's goals and objectives. For example, if management feels high quality is essential toward achieving its goals, it will stress quality in its evaluation of its employees. On the other hand, a company that wants to expand rapidly and needs to acquire contract work, tends to stress proposal work. It may even sacrifice quality of workmanship in order to do this. As an initial trial the model assumes that with a work backlog of two man years of contract work, the company sets the evaluation weights at 50 percent on contracts and 50 per cent on proposals. Figure 3.19 relates the evaluation weights to work backlog.

As an evaluation can vary from week to week, the company averages this total evaluation over a six month period to arrive at an evaluation which it uses to administer wage increases and promotions. Initially this evaluation is set at 1 or normal evaluation on a scale from a low of 0 to a high of 2.

\[
\text{LEVAL}_K = (\text{CWF}_K)(\text{ECW}_K)+(\text{PWF}_K)(\text{EPW}_K) \quad 74, A
\]
\[
\text{PWF}_K = 1 - \text{CWF}_K \quad 75, A
\]
\[
\text{CWF}_K = \text{TABHL}(\text{TCWF}_K, \text{CIH}_K, 0, 4, 1) \quad 76, A
\]
\[
\text{TCWF}_K = 0/ .25/ .5/ .75/ 1 \quad 76.1, C
\]
\[
\text{CE}_K = \text{CE}_J + (\text{DT})(1/ \text{DEVAL})(\text{LEVAL}_J - \text{CE}_J) \quad 77, L
\]
Figure 3.19 Extent of Emphasis Placed on Contract Work in the Evaluation Process
CE = CEIN
CEIN = 1

DEVAL = 6 months

LEVAL - Instantaneous Evaluation
CWF - Contract Weighting Factor
TCWF - Table, Contract Weighting Factor
PWF - Proposal Weighting Factor
ECW - Evaluated Contract Worth
EPW - Evaluated Proposal Worth
CIH - Contracts in House
CE - Company Evaluation
CEIN - Initial, Company Evaluation
DEVAL - Delay to Evaluate

This section constructs a simple performance evaluation technique for measuring professional performance. It explores linkages L and M in Figure 3.1.

Incentives

Once the company has evaluated professional performance, it uses this evaluation to provide rewards and advice to the individual. In this way management lives up to its part of the bargain in the "psychological contract" between the employer and the employee. Most organizations have elaborate incentive plans designed to motivate the employee toward greater productivity. These plans can involve stock options, special awards, bonuses, etc. Most of these plans can be classified, according to A. H. Maslow,\(^{19}\) as to the basic human need which they seek to satisfy. Viewed in this way, all incentives fall into two categories. One is the economic reward which satisfies the

basic human need for security. Economic rewards involve the improvement of an individual's monetary position. The other type of incentive is designed to satisfy an individual's need for status, prestige, self-esteem, etc. These incentives involve recognition of achievement. Both types of incentives are rewards. They are usually highly correlated. A salary increase to a professional technical employee serves more as a status symbol than as a source of economic security. This is because in the knowledge industry salaries tend not only to be adequate, but also quite uniform.

The salary an individual receives is a level determined by his monthly increases. Initially the engineer joins the firm at $8000 a year. The salary increases are clearly related to the evaluation of his technical performance. Figure 3.20 illustrates the relevant relationship. As evaluation increases, raises may be as great as two and one half times the average increase to which the engineer has become accustomed. An employee whose evaluation does not meet company expectations receives an increase below his expectations or may not receive any raise at all.

\[ S.K = S.J + (DT)(SI.JK + 0) \]
\[ S = IS \]
\[ IS = 8000 \text{ dollars} \]
\[ SI.XL = (PSI.K)(ESI.K) \]
\[ PSI.K = TABHL(TPSI,CE.K,0,2,.5) \]
\[ TPSI* = 0/0/1/1.75/2.5 \]
Per Cent Increase of Expected Salary

Figure 3.20 Salary Increase
S  - Salary
SI - Salary Increase
IS - Initial Salary
PSI - Per Cent Salary Increase
TPSI - Table, Per Cent Salary Increase
ESI - Expected Salary Increase
CE - Company Evaluation

In addition to salary benefits the model includes promotions as part of its reward structure. Promotions, as used in this thesis, refers to any incentive whose basic intent is to satisfy an individual's need for recognition. Promotions have psychological rather than monetary value, although the two are not independent. The equations which define the promotional reward structure of the model are essentially the same as those which define the salary reward structure. The per cent increase in position relative to expected is plotted vs. company evaluation in Figure 3.21.

\[ PC.K = PC.J + (DT)(PI.JK+0) \]
\[ PC = PCI \]
\[ PCI = 1 \]
\[ PI.KL = (PPI.K)(EPI.K) \]
\[ PPI.K = TABHL(TPPI,CE.K,0,2,.5) \]
\[ TPPI* = 0/0/1/1.5/2.5 \]

PC  - Position in Company
PI  - Position Increase
PCI - Initial Position in Company
PPI - Per Cent Position Increase
TPPI - Table, Per Cent Position Increase
EPI - Expected Position Increase
CE - Company Evaluation
The incentive scheme just described deals with rewards, the basic inducements a company can offer to an employee who has a better than normal performance record. The company must also have a mechanism for informing the employee when he is not meeting company expectations. In most companies this is accomplished by holding a performance review. At this meeting between the staff member and a representative of management, the staff member is told of the areas in which he must improve his work. The model defines this as company pressure. The pressure can either be to improve proposal work or contract work. The extent of this pressure is determined by the disparity between performance and expectations. Figure 3.22 graphically depicts both contract and proposal pressure vs. evaluation.

\[ PPW.K = \text{TABHL}(TPPW, EPW.K, 0, 2, .5) \]

\[ TPPW* = 3/2/1/.25/0 \]

\[ PCW.K = \text{TABHL}(TPCW, ECW.K, 0, 2, .5) \]

\[ TPCW* = 3/2/1/.25/0 \]

- PPW - Pressure to do Proposal Work
- TPPW - Table, Pressure to do Proposal Work
- EPW - Evaluated Proposal Work
- PCW - Pressure to do Contract Work
- TPCW - Table, Pressure to do Contract Work
- ECW - Evaluated Contract Work

This section refers to linkage \( N \) on Figure 3.1 and closes all the major feedback loops. The Industrial Dynamics model is now complete except for an exogenous input which provides the driving force to the system.
Figure 3.21 Position Increase
Figure 3.22 Pressure to Improve Performance
Exogenous Input

The model provides a structure with which to analyze employer-employee interaction in a professional environment. The company evaluation of professional performance serves as the basis for the incentives offered to the staff member. These incentives induce levels of motivation in the employee which ultimately effect his professional performance. The one factor missing from the analysis is the technical experience and competence which the professional brings with him to the organization. This is a natural characteristic, and although the company may succeed in establishing an environment conducive to bringing out all the best qualities in the individual, it cannot cause him to attain standards of performance which are higher than those to which his natural capabilities limit him.

Four different inputs will be applied to the system. The first will represent a highly qualified employee. The technical experience and capability of this employee relative to an assumed industry standard is graphed in Figure 3.23A. After four years this engineer is 36 per cent "better" than normal.

\[
\begin{align*}
\text{TEC} & = \text{TEC1} + \text{TEC2} \\
\text{TEC1} & = \text{RAMP}(0.01,12) \\
\text{TEC2} & = \text{RAMP}(-0.01,48)
\end{align*}
\]

TEC - Technical Experience and Capability
The second input represents an engineer who due to a better background and training is more competent than an average engineer. However, after five years whatever advantages he has disappear. He returns to the level of an average engineer as shown in Figure 3.23B.

\[ \text{TEC}.K = \text{TEC1}.K + \text{TEC2}.K + \text{TEC3}.K \]
\[ \text{TEC1}.K = \text{RAMP}(+.01,12) \]
\[ \text{TEC1} = \text{I} \]
\[ \text{TEC2}.K = \text{RAMP}(-.02,36) \]
\[ \text{TEC3}.K = \text{RAMP}(+.01,60) \]

**TEC - Technical Experience and Capability**

The third input represents a professional employee who just "hasn't got it." His technical competence is plotted in Figure 3.23C and after four years his competence relative to others is 18 per cent below normal.

\[ \text{TEC}.K = \text{TEC1}.K + \text{TEC2}.K \]
\[ \text{TEC1}.K = \text{RAMP}(-.005,12) \]
\[ \text{TEC1} = \text{I} \]
\[ \text{TEC2}.K = \text{RAMP}(+.005,48) \]

**TEC - Technical Experience and Capability**

The fourth and last input to the model represents an engineer who because of poor background and training, initially, falls below normal capabilities. However, as illustrated in Figure 3.23D, he recovers from these initial deficiencies and after five years performs as an average engineer.
TEC\_K = TEC1\_K + TEC2\_K + TEC3\_K
TEC1\_K = RAMP(-0.01, 12)
TEC1 = I
TEC2\_K = RAMP(+0.02, 36)
TEC3\_K = RAMP(-0.01, 60)

TEC - Technical Experience and Capability

These four inputs are now applied to the Industrial Dynamics model and the simulation results are analyzed in the next chapter.
Technical Experience and Competence

A. Above Average Engineer

B. Engineer Loses Advantages

C. Below Average Engineer

D. Engineer Loses and Regains

Figure 3.23 Exogenous Input
CHAPTER 4

BEHAVIOR OF THE MODEL

Before investigating the behavior of the model just described, it is important to realize its limitations. The model is not intended to be an accurate description of a real world situation. Instead the purpose of the model is to provide a tool to help in understanding a general problem; namely, the implications of management's appraisal-incentive policy on professional performance. In fact many interactions were purposely simplified and others were left out so as not to distort the influences which directly effect the basic system. It is extremely difficult to make meaningful quantitative statements concerning such intangible factors as motivation, interaction, and satisfaction. These limitations make it impossible to use the model to either accurately predict behavior of the real-world system or to explicitly determine real-world actions which might improve system behavior.

The model is best understood by realizing that it is a complex feedback structure. The interaction of the important feedback loops and the time delays inherent in the causal system determine its behavior. It is this overall behavior of the model which is important. In order to emphasize its loop structure, the model is redrawn in Figure 4.1. There are a total of eight independent feedback loops in this system.
Two of these loops are basic to any system relating management's appraisal-incentive policy to professional performance. These are drawn separately in Figure 4.2 and Figure 4.3. The causal linkages in these two loops have been the source of numerous studies. Indeed, the "psychological contract" between an organization and its members, which was mentioned in an earlier chapter, specifically refers to these loops.

Feedback loops can be characterized as either positive or negative. A positive loop is one in which an increase (decrease) in one variable in the loop results through a series of causal interactions in a further increase (decrease) in that variable. Figure 4.2 represents a positive loop because an increase in performance leads to a more favorable evaluation, higher incentives, stronger motivation to work, and finally a further increase in performance. The feedback loop in Figure 4.3 is negative, because an increase in performance leads to a decrease in pressure and a lessening in motivation which results in a decrease in performance. Management is concerned with the interaction of these two loops. Clearly if an employee is performing well; i.e., above company expectations, loop 1, relating rewards to performance, dominates his behavior, whereas for a "poor" employee loop2, relating pressure to performance, becomes the most important factor.

The point of view taken in this thesis is that for a professional employee in the knowledge industry these two loops are only part of the
Figure 4.1 Overall Feedback Loop Structure of the Model
Figure 4.2 Loop 1, Positive Loop Relating Rewards to Performance

Figure 4.3 Loop 2, Relating Pressure to Performance-Negative Loop
system's structure which determines his performance as it is affected by company policy. Consider the professional staff member who is not meeting company expectations. His performance is dependent on the loop depicted in Figure 4.4. This is a positive loop because as performance increases the employer feel less pressure to produce, can spend more time interacting, increases his cooperative efforts which results in a further increase in performance. Viewed in another way, an individual who is under pressure is forced to limit his interaction which will decrease his performance still further, especially if interaction, in the form of cooperation, is an important influence in determining performance.

On the other hand, Figure 4.5 depicts a negative loop which is an important determinant of system behavior when interaction gets too high. The effect of this loop is to force a professional employee, who is not meeting company expectation, to use his time more efficiently and in this way improve his performance.

The case of a professional who is performing above standard and is therefore motivated by the rewards he receives rather than any threat to his job security, is more complex. He must correlate these rewards with his perception of the cohesiveness of the groups with which he associates. In the strictest sense, this situation cannot be represented by either a positive or a negative feedback loop. Figure 4.6 illustrates
Figure 4.4 Loop 3, Positive Loop Relating Pressure to Cooperation

Figure 4.5 Loop 4, Negative Loop Relating Pressure To Use Of Time
the loop in question, but whether it is positive or negative depends on the extent of group cohesion in the company. If group cohesion is high then this is a positive feedback loop in that a reward causes greater cooperation, higher performance, and further rewards. In the case of low group cohesion a reward for high performance is interpreted by the staff member as an indication that group cohesion is unimportant in determining the rewards he receives and thus induces him to work by himself to a greater extent. This has a detrimental effect on his performance and he does not receive any new increases in rewards.

Similarly loop 6 in Figure 4.7 depends on the extent of group cohesion. Consider the situation where group cohesion is high. An increase in rewards is interpreted by the staff member as approval of his interaction and therefore it reinforces this action. The resulting increase in interaction lowers the efficiency with which he performs his tasks and therefore lowers his performance. Subsequently his rewards are decreased. This feedback loop is therefore negative when cohesion is high. A similar analysis indicates that loop 6 is positive if cohesion is low.

This completes the analysis of those feedback loops which are directly related to the company's appraisal-incentive policy. The situation is very complex!

The model contains two more feedback loops which pertain to the effect of interaction on further interaction. Figure 4.8 illustrates
Figure 4.6 Loop 5 Relating Rewards to Cooperation

Figure 4.7 Loop 6 Relating Rewards to Use of Time
a simple positive loop which shows that increased interaction increases the individual's motivation to interact and leads to a further increase in interaction.

The final feedback loop in the overall system is illustrated in Figure 4.9. It is a positive loop in that as interaction increases, an individual becomes more highly motivated to work and also to interact. These positive loops express the psychological fact that people need to socially interact and that when this need is satisfied they are strongly motivated. Both loops 7 and 8 have the effect of perpetuating any upward or downward trend in interaction. It might be suspected that because of these two loops extreme degrees of interaction might occur in the behavior of the model.

The preceding analysis of the loop structure of the model serves as a basis for understanding model behavior. The first simulation run is illustrated in Figure 4.10. It is a simulation of the basic model developed in Chapter 3. The exogenous input depicts an engineer whose technical experience and competence is 36 per cent above average after four years. The run starts out in the steady-state until the exogenous input begins to push quality higher in the twelfth month. As quality increases, the employee's evaluation also increases and his actions are dominated by the rewards he receives. Loop 1, which relates rewards to performance, tends to drive evaluation still higher. Increased rewards correlated with group cohesion induce the employee to increase his interaction, i.e., loop 5. As interaction increases loops 7 and 8 cause him
Figure 4.8 Loop 7, Positive Loop Relating Interaction to Motivation to Interact

Figure 4.9 Loop 8, Positive Loop Relating Interaction and Motivation
to further increase his interaction. Everything seems to be going well. Performance is increasing even after the exogenous input is "turned off." Interaction is high and an atmosphere of cooperation exists.

However, in the 60th month this increased interaction starts to lead to "goofing off" and inefficient use of time. Proposal worth no longer increases, but instead starts to decrease. Then in the 76th month trouble develops for the first time. Proposal worth falls below company expectations as the engineer is only using 70 per cent of his time efficiently. Although the company exerts pressure on the employee to improve his performance, loops 7 and 8 are reinforcing this causal, inefficient atmosphere until in the 92nd month only 40 per cent of the engineer's time is being used efficiently. By this time his proposal work is so poor that the employee's total evaluation falls below company expectations and the company exerts pressure on the engineer to improve his performance. This pressure feeds through loops 4 to cause an employee to use his time more efficiently. Thus interaction starts to decrease. At the engineer uses more of his time efficiently his performance on proposals and contracts improves until in the 104th month, his total evaluation is above normal again. Due to the delays in the system his interaction continues to fall until month 120. At this point group cohesion is still strong, social interaction is slightly greater than usual, rewards are increasing, and in general the employee is doing well once more.
The situation remains stable for only a short period of time, however. Interaction begins to climb again, essentially by the mechanism of loops 1 and 5. The subsequent inefficient use of time which results from more interaction causes his performance to become poorer as early as the 128th month. The positive feedback influence of loops 7 and 8 drive interaction still higher and in the 136th month proposal worth falls below normal again. It is interesting to note that motivation to work has been high the entire time. The fluctuations in performance are caused by changed in the social atmosphere rather than by wide changes in motivation.

It is not until the 152nd month that the engineer's total evaluation falls below company standards. At this time only 50 per cent of the time is being used efficiently. As pressure builds up to improve performance interaction again tends to decrease. The fluctuations in interaction are not as great any more primarily because loops 7 and 8 are not contributing as strongly as they once did. The entire process now repeats. Greater efficiency, accompanies falling interaction until in the 164th month the engineer's total evaluation is again above average.

From this time until the end of the run, evaluation remains above company standards, but not as much as would be expected of an engineer who is supposedly 36 per cent more competent than the average. Why is this so? The main reason appears to be because of his high level of
interaction. He appears to be able to attain adequate rewards while utilizing only 70 per cent of his time efficiently. His motivation to work is still high but it only balances the poor efficiency at which he works. Fluctuations in interaction still occur, but they are not as noticeable at this high level of interaction.

Some very interesting conclusions can be drawn from this basic run. If a standard is needed by which to judge the staff member's performance, one might be that his salary was $29,268 after 200 months with the company. This standard is not too useful as it fails to give any meaningful information as to the variations of performance as he was achieving this final level of salary. A better indicator of the variations in performance might be the rate at which contracts were awarded. These fluctuated from a low of .115 contracts per month to a high of .178 contracts per month. The remarkable fact that his evaluation twice fell below that of the average engineer's is evidence of the importance of interaction on professional performance. The fluctuations in this performance are directly traceable to fluctuations in interaction.

A second simulation is illustrated in Fig. 4.11. It demonstrates model behavior in the case of an engineer who at first has better than average experience and competence, but who, after his fifth year, has lost all of advantages over the average engineer. This simulation is quite similar to that shown in Figure 4.10. As quality starts to
Figure 4.11 Basic Model - Engineer Loses an Initial Advantage
increase as a result of the exogenous input in the twelfth month, so does the total evaluation and the extent of interaction. As in the first simulation, by the 40th month the engineer's position looks quite favorable. Quality starts to fall as he loses his initial advantage in competence, but still his strong interaction and cooperation allows him to remain with a favorable evaluation. Interaction continues to increase, however, and in the 80th month due to growing inefficiencies in this use of time, proposal worth drops below company standards. Again as in the first simulation this soon leads to a total evaluation which is below average. Although the company exerts pressure on the individual in an attempt to improve his performance, interaction still grows because of loops 7 and 8, until in the 108th month the increase in pressure forces the engineer to curtail his social interaction. The remainder of this run is not significantly different from the run in Figure 4.10. The system fluctuates in much the same manner, except because technical experience is only average, proposal worth, not helped particularly by the high level of cooperation, remains continuously poor. Because the project teams are cooperating, quality remains high, although the engineer's overall evaluation fluctuates above and below average. In this run also the same observation can be made, namely that an engineer with average capabilities still has his performance fall below company expectations during much of his tenure with the company. This is traceable to his inefficient use of time as a result of very high interaction.
The third map pictured in Figure 4.12 is a simulation of an employee who is below average in his technical capabilities and experience. The run starts in the steady-state, but after twelve months the exogenous input causes quality to fall below company expectations. As quality continues to fall, the company exerts pressure on the staff member to improve his performance. This pressure has the effect of limiting his interaction and curtailing his cooperative efforts. Pressure continues to increase and its effect of motivating the engineer to work harder balances, for a short period of time, his loss of motivation from only weak social ties with his associates. As loops 7 and 8 drive interaction still lower the harassed engineer is forced to spend most of his time working as hard as possible to avoid losing his job. He has little contact, outside of necessary situations, with his colleagues.

Note that except for loop 2 all the important feedback loops are helping to drive interaction to zero and performance as low as possible. There seems to be nothing in the model to cause the engineer to cooperate when an atmosphere of competition and low group cohesion exists. Essentially he is fighting for his job security and the company has done nothing to inform him of the need to cooperate in order to improve his performance. After 100 months, interaction has dropped to 0 and company pressure is 58 per cent above normal. All this tends to do is keep his quality of contract work and performance from falling below its now stabilized value of 55 per cent of normal. The only factor which prevents his total evaluation from dropping more than the 14 per cent below normal that it
Figure 4.12  Basic Model - Below Average Engineer
does is the weak dependence of proposal writing on technical competence and extent of interaction. After 200 months the engineer's salary is only $16,000 and the typical picture of an engineer trapped in a company with no resource than to "stick-it-out" has appeared.

The final run of the basic model is shown in Figure 4.13. It represents the behavior of an engineer who because of his lack of training temporarily falls below average. However, he soon recovers the ground he has lost and after his fifth year is as competent as an average engineer in the industry. This run appears quite similar to the last run. As in the run in Figure 4.12 the exogenous input forces quality below average after the twelfth month. Pressure to improve quality is exerted on the engineer until in the 28th month as a result of this pressure, combined with his personal recovery in terms of experience, quality begins to improve. The improvement continues until the 40th month and then it starts to fall again. This occurs because the initial pressure exerted by the company on the individual forced him to limit his extent of interaction. As group cohesion fell, loops 7 and 8 reinforced this growing lack of cohesion and forced him (as Maslow would say)\(^1\) to seek identification with others, rather than the project teams to which he was assigned. By the 40th month, cooperation is low enough so as to prevent him from reaching normal quality work. Proposal work is high enough at this time that his overall evaluation is only slightly below average. But things get worse from here on. Again, as in the previous run, all the loops which are governing

Figure 4.13 Basic Model - Engineer Recovers Initial Deficiencies
model behavior combine to drive interaction toward zero. Only his strong motivation to work, as a result of the constant pressure, keeps the employee from floundering completely. But this is not enough to prevent him after the 100th month to stabilize at a scale value of quality of contract work equal to .63 or 37 per cent below average. His total evaluation is only 14 per cent below average due in part to the fact that as his contract backlog of work has dropped to almost nill, he is evaluated primarily on proposal work which does not depend on interaction to that great an extent. After 200 months his salary reaches at a level of approximately $17,000. And yet although this professional has normal capabilities and experience, he performs poorly and does not cooperate!

An analysis of all four simulation runs reveals two important observations.

1.) The "natural forces" which prevent interaction from reaching extremes do not exist. An employee who is doing poorly is forced to compete in order to outperform his colleagues and this competition produces an unhealthy company atmosphere. On the other hand, an employee who is more capable than the average staff member tends to "goof off" if left on his own. This tendancy prevents him from achieving the outstanding performance of which he is capable. Douglas McGregor is quite right when he stated that many employees sacrifice salary raises and promotions in order to win the approval and acceptance of their colleagues.²

The reader may feel that the importance attributed to interaction and its effect on professional performance is exaggerated. This is, perhaps, true. Clearly interaction is somewhat more important to a company in the knowledge industry than it is to companies in other industries. Whether or not this importance is exaggerated, the model points out the difficulties and problems which occur when management does not actively monitor and influence the extent of interaction of its employees.

2.) It appears that a professional staff member's initial motivation to interact or not interact is a most important determinant of overall system behavior. If he starts out on the right foot and cooperates, interacts, builds up strong group associations, he does well. If he initially works more by himself, makes associations outside his immediate colleagues, and limits his social interaction, he does poorly. The factor which determines this initial motivation to interact appears to be whether he perceives himself to be in the eyes of the company evaluation a better than average engineer or a below average engineer. If he feels that his capabilities are not equivalent to company standards he pushes himself at the expense of socially interacting. But if he feels himself more capable than the average engineer in the company, quite the opposite situation occurs.

In the next chapter the original hypotheses developed in Chapter 1 will be explored. After that an improved appraisal-incentive policy which tries to regulate the extent of interaction among employees will be tested.
CHAPTER 5
DEVELOPMENT OF A REVISED MODEL

In Chapter 1 it was stated that management often emphasizes the importance of proposal preparation and writing as means of inducing rapid company growth. One of the original hypotheses of this thesis was that if management relaxed this pressure to turn out proposals and made a conscious effort to insure higher quality contract work, the effect might be to increase the staff member's productivity and consequently, the company's growth. In order to test this hypothesis a change has to be made in the company evaluation policy. In the basic model, an employee's evaluation, with two man-years backlog of contract work, was still dependent on his efforts to solicit more business, i.e. his proposal work. If he wished to maximize his evaluation he had to devote half his efforts to preparing proposals. The exact relationship between backlog of contract work and division of evaluation weights was illustrated in Figure 3.19. It is decided to change this relationship to the one pictured in Figure 5.1. The staff-member now can devote full time to working on contracts when he has a backlog exceeding two man-years of work without fear that this will lower his evaluation. To implement this change in the model equation 76.1,C is revised to

\[
TCWF* = 0.5/1/1/1
\]

TCWF - Table, Contract Weighting Factor
Figure 5.1  Extent of Emphasis Placed on Contract Work in the Evaluation Process - Revised
With this change in the basic model, a new simulation is run-Figure 5.2. The input represents an engineer with better than average technical experience and capabilities. A comparison of this run with the one pictured in Figure 4.10 reveals quite different system behavior. In both runs quality increases from the twelfth to 48th month as a result of the exogenous input. However, in the new run the engineer is evaluated almost exclusively on his contract work, as he initially had a large backlog of work. The evaluation thus tends to amplify his superior technical competence and his evaluation after 48 months is 5 per cent higher than in the original run. In both runs, rewards correlated with group cohesion drive the engineer toward greater interaction. In the 60th month evaluation has increased to a ten per cent better rating than before. Essentially all the loops which combine to drive performance and interaction upward are behaving as they did in the previous run except their effect is even more pronounced, primarily because of the higher evaluation and subsequent higher rewards. Whereas before, increasing interaction led to a situation after 76 months in which the staff member was only utilizing 70 per cent of his time effectively, now only 55 per cent of his time is effectively utilized. Although proposal worth falls below company expectations in the 72nd month, the total company evaluation remains above average as a result of the very weak emphasis placed on proposal writing. Interaction continues to rise until the 84th month when suddenly the situations begin to deteriorate. At this time only 30 per cent of the engineer's time is used effectively
Figure 5.2 Basic Model - Above Average Engineer
Emphasis on Quality
and quality starts to fall. The fact that proposal worth has been poor for some time results in a swift decline in new contract awards. As the backlog of oncontract work decreases more emphasis is placed on proposal writing which is already 40 per cent below average. The net effect is to drive evaluation downward and at the same time increase pressure significantly. The increased pressure forces the engineer to use his time more efficiently. This pressure is quite a bit stronger than was necessary in the earlier run.

As efficiency increases, quality and proposal worth both rise. As a result total evaluation starts to improve again by the 96th month. However the strong pressure has continued to drive interaction to a lower and lower level. And then in the 100th month group cohesion disastrously drops below normal! Now the increase in rewards, due in fact to more efficient use of time, is perceived by the staff member as reward for his more individual efforts. The rewards cause him to interact to even a lesser extent and indeed a situation has developed where he competes rather than cooperates with his colleagues. As a result of poor cooperation and decreased communication, both quality of work and proposal worth fall below company expectations. In the 128th month company evaluation of his total performance drops below average. Now the pressure exerted on him drives interaction still lower. The situation becomes progressively worse until in the 140th month interaction is practically nil and the engineer must compete simply to remain employed.
The explanation as to why the system behaved poorly can again be traced to the uncontrolled fluctuations in social interaction. In this run an initially sound idea backfired as the engineer did so well at first, he found he "could get away" with very little work. When it suddenly became obvious that his goofing off was leading to trouble, he was already in serious danger of losing his job. His reaction to this crisis was to curtail his interaction and use his time more efficiently. But in the process an atmosphere of competition developed, a situation from which there seems to be no recovery. It is clear that relaxing pressure to turn out proposals may be a good idea if interaction is somehow controlled, but in this basic model it does not lead to better model behavior.

The question arises, is it better to relax pressure to turn out proposals in the case of an engineer with below average capabilities? The answer is supplied by the run pictured in Figure 5.3. A comparison of this run with the one in Figure 4.12 reveals that an evaluation policy which emphasizes contract quality simply amplifies the deficiencies of this engineer. As the evaluation is more heavily weighted toward quality, these deficiencies are more obvious. This magnifies the pressure exerted on him and causes his performance to fall. Lower performance occurs not because he isn't motivated to work hard; he is. Rather it occurs because he is essentially competing rather than cooperating with the other staff members.
Figure 5.3 Basic Model - Below Average Engineer
Emphasis on Quality
A second hypothesis made in Chapter 1 concerns the lack of communication between management and the staff member as to the relative weight contract or proposal work carry in the company's evaluation policy. In a sense, these weights reflect company philosophy. A company which stresses high quality work will evaluate its employees primarily on their quality of work. It was suggested that if management keeps the engineer informed as to the standards by which he is being evaluated, it would help to improve his performance.

In order to test this idea it is decided to set up monthly meetings with the staff in order to review company goals and policies. These meetings guide the staff members in their actions, and insure communication directly between management and staff. To implement this situation in the model DOWF is reduced from 24 months to one month.

\[ \text{DOWF} = 1 \text{ month} \]

The effect of this change is to reduce the engineer's perception of the standards by which he is evaluated from an average smoothed over 24 months to an average smoothed over only one month. With this change in the basic model, a new run is simulated. Figure 5.4 represents the result of this run. The input to the system is an above average engineer. A comparison of this run with the one in Figure 4.10 reveals essentially the same system behavior.

One possible explanation for the lack of significance that a change in DOWF produces in model behavior, is the following. The weighted average of proposal work and contract work, which the company uses to achieve a
total evaluation, depends only on the backlog of in-house contracts. During the course of the run this backlog does not vary much. Thus an average over 24 months is almost the same as an average over one month. As a result, the employee's perception of how he is being evaluated is quite accurate. There is no disequilibrium between management's evaluation policy and the employee's perception of this policy.

A simulation involving a below average engineer also reveals almost no difference in model behavior. Basically this is because this employee is always under pressure. The extent of pressure therefore provides guidance as to how he should spend his energies.

It is clear throughout the analysis of the basic model that the dominant characteristic of the system is the uncontrolled fluctuations in interaction. Natural forces do not exist which limit extremely low or extremely high interaction. In the present model management's only control over the system is in its evaluation of professional performance and the incentives it offers as a result of this evaluation. This form of control has three serious disadvantages.

1.) Changes in performance caused by fluctuations in the extent of interaction are observed too late for the company to take effective corrective measures. For example, if interaction gets too high, it decreases performance because the employee is inefficient. The company, reacting to lower performance, exerts pressure on the individual which forces him to use his time more effectively. But by the time this pressure has fed back through the system the situation has gotten
progressively worse. Because of the time delays it now requires much more additional pressure to help correct the situation.

2.) Management's only control over the staff member's behavior is through the incentives with which it motivates him. The effect of these incentives on his behavior may be exactly opposite to what the company had hoped it would be. For example, a reward amplifies an individual's actions. Therefore a reward received because the individual increased his performance by utilizing his time more efficiently, may be perceived by the individual instead as a sign that management is encouraging individual rather than group efforts. In an extreme case, this might lead to competition between the staff members, a situation management did not want to occur.

3.) Management may misinterpret the cause of fluctuations in performance. If performance declines, management may feel that the employee is not working hard enough and pressure him to work more intensely. However if the decline in performance is due instead to less cooperation between the staff members, this pressure will have exactly the opposite effect of decreasing cooperation; and, subsequently, lowering performance still further.

In order to improve the situation a major change must be made in the feedback structure of the system. The company needs to be able to
continually monitor the extent of interaction of its employees and be
able to influence it directly. The new system is drawn in Figure 5.5.
It is clear from this diagram that management has established a second
means of controlling the behavior of its employees. Realizing the
importance of interaction as a determinant of professional performance,
it hopes to prevent interaction from getting out of control. Changes must
be made in the basic model developed in Chapter 3 in order to implement
this new system. First, the company must observe interaction. It then
must compare this observed value to a desired level. The model formu-
lates observed interaction as a level smoothed over six months of actual
interaction. The desired level of interaction is set at 5, a level
which provides for the most interaction possible without appreciable
"goofing off."

\[
\text{OSIN}_K = \text{OSIN}_J + (DT)(1/\text{DOIN})(\text{SIN}_J - \text{OSIN}_J)
\]

\[
\text{OSIN} = \text{SIN}
\]

\[
\text{DOIN} = \text{6 months}
\]

\[
\text{EVIN}_K = \text{OSIN}_K/\text{DSIN}
\]

\[
\text{DSIN} = 5
\]

OSIN - Observed Social Interaction
SIN - Social Interaction
DOIN - Delay to Observe Interaction
EVIN - Evaluated Interaction
DSIN - Desired Social Interaction

On the basis of this comparison management either decides to encourage
more cooperation, or pressure the employee into less interaction and more
Figure 5.5 Revised System - Causal Interaction of Key Variables
efficient use of his time. A program to encourage cooperation, especially when a competitive atmosphere already exists, requires a great deal of conscious effort. Management must convince the staff members that they will not be penalized for spending more time engaged in social rather than task-oriented activities. Weekly staff meetings, company picnics, softball and bridge leagues, etc., all help to reinforce this idea. Even with all this effort the process is very slow.

Decreasing interaction is probably an easier task. Management makes it clear "goofing off" will not be tolerated. Individuals are discouraged from gathering for bull sessions. The need for a formal business atmosphere is impressed on the staff.

The extent of management's policies to encourage or discourage interaction depends on how much disparity there exists between observed and desired interaction. Clearly as the extent of interaction becomes more extreme, management must exert more effort to correct the situation. The relationship between this disparity and company efforts is plotted in Figures 5.6 and 5.7.

\[ EMIN.K = \text{TABHL}(TEMIN,EVIN.K,0,1,.2) \]
\[ TEMIN* = .5/.4/.3/.2/.1/0 \]
\[ PLIN.K = \text{TABHL}(TPLLN,EVIN.K,1,2,.2) \]
\[ TPLIN* = 0/.1/.2/.3/.4/.5 \]

- **EMIN** - Encouragement of More Interaction
- **TEMIN** - Table, Encouragement of More Interaction
- **PLIN** - Pressure For Less Interaction
- **TPLIN** - Table, Pressure For Less Interaction
- **EVIN** - Evaluated Interaction
Figure 5.6 Company Encouragement of Increased Interaction

Figure 5.7 Company Pressure to Decrease Interaction
The effect of these company efforts is to establish a level of induced motivation to interact within the staff member. This level develops over a period of time. As mentioned before programs which attempt to increase interaction are much harder to implement than programs which attempt to limit interaction. Perhaps this is because individuals are conditioned to believe that work is a non-nonsense activity, a throw-back to McGregor's Theory X.\(^1\) To account for this, changes which tend to increase interaction take twelve months to take effect, whereas changes which tend to decrease interaction take only three months to take effect.

\[
\begin{align*}
\text{MIN}_K &= \text{MIN}_J + (\text{DT})(1/\text{MIN})(\text{MIN}_J - \text{MIN}_J) \\
\text{MIN} &= 0 \\
\text{D.MIN} &= 12 \text{ months} \\
\text{LIN}_K &= \text{LIN}_J + (\text{DT})(1/\text{LIN})(\text{LIN}_J - \text{LIN}_J) \\
\text{LIN} &= 0 \\
\text{D.LIN} &= 3 \text{ months}
\end{align*}
\]

\(\text{MIN} \) - Motivation for More Interaction  \\
\(\text{MIN} \) - Encouragement of More Interaction  \\
\(\text{D.MIN} \) - Delay for More Interaction  \\
\(\text{D.LIN} \) - Delay for Less Interaction  \\
\(\text{LIN} \) - Motivation for Less Interaction  \\
\(\text{D.LIN} \) - Pressure for Less Interaction

There are two results of management's policies to control interaction. The first is the direct effect on interaction itself. The induced levels of motivation just formulated cause a percentage change in interaction. A graph of this percent change vs. extent of induced motivation is plotted

in Figure 5.8. The change is added to the change in interaction caused by the individual's natural desires to interact which was formulated in Chapter 3.

\[
\begin{align*}
\text{CSIN}.K &= (\text{SIN}.K)(\text{PCSIN}.K+\text{ICSIN}.K) & 44,R \\
\text{ICSIN}.K &= \text{TABHL}(\text{TCSIN},\text{IMIN}.K^{.5},+.5,+2) & 92,R \\
\text{TCSIN}^* &= -.3/-25/-15/+15/+25/+3 & 92.1,C
\end{align*}
\]

SIN - Social Interaction  
CSIN - Change in Social Interaction  
PCSIN - Per Cent Change in Social Interaction  
ICSIN - Induced Change in Social Interaction  
TCSIN - Table, Change in Social Interaction  
IMIN - Induced Motivation to Interact

The second result of management's policies to control interaction is to affect the individual's utilization of time. Any policy which seeks to encourage interaction must at the same time allow the individual to spend more time on non-task oriented activities. Thus this employee does not use his time as effectively as he did before. On the other hand, an employee who is discouraged from interacting has more time to devote to company business. Thus, he uses his time more efficiently. These ideas are incorporated into the revised model by the following equations.

\[
\begin{align*}
\text{IMIN}.K &= \text{MMIN}.K-M\text{LIN}.K & 92,A \\
\text{IMEP}.K &= 1-\text{MIN}.K & 93,A \\
\text{UT}.K &= (\text{IMEP}.K)(\text{EUT}.K) & 94,A \\
\text{TPC}.K &= (\text{UT}.K)(\text{TEC}.K)(\text{MCW}.K)/(1)(1)(\text{NMOW}) & 50,A
\end{align*}
\]

IMIN - Induced Motivation to Interact  
MLIN - Motivation for Less Interaction  
MMIN - Motivation for More Interaction  
IMEP - Induced Motivation Effect on Performance
Figure 5.8 Induce Percentage Change in Social Interaction
This completes the revision of the model. A new simulation was run with an above average engineer representing the input. The result of this simulation is illustrated in Figure 5.9. As before, quality of contract work rises from the twelfth to 48th month due to the influence of the exogenous input. The increase in quality leads to better performance and increased rewards. In the basic model this led to a situation of increasing interaction and eventually very inefficient use of time. However, as the employee attempts to increase his interaction, the company discourages him from doing so. Notice how little pressure the company needs to use, because it is "nipping the problem in the bud" before it gets out of hand as it did previously. There are some very mild fluctuations at the end of the run which are caused by the short delays required for the company to notice an increase in interaction and then institute a policy to correct the situation. But the wild fluctuations are completely absent and this engineer continually does above average work throughout the run.

Figure 5.10 represents a simulation run of an engineer who initially has better than average capabilities. However, after five years all his advantages have disappeared and his competence falls to average. Again it is clear that the problems which confronted the previous run with the
Figure 5.10 Revised Model - Engineer Loses Initial Advantages
basic model have been eliminated; the engineer's productivity is uniform and limited only by his natural capabilities. The only problem is that in the twelfth month the company reacts too strongly to increasing interaction and causes a situation where interaction drops slightly below normal. The result is that competition develops which tends to lower quality and pull the total evaluation below average. The company reacts by encouraging stronger interaction and the situation remains only mildly unstable. The instability exists because, on one hand the company is exerting pressure to increase performance which tends to force less interaction, while on the other it attempts to encourage cooperation through the various schemes mentioned earlier in this chapter.

The next simulation represents the behavior of a below average engineer under the revised model. Figure 5.11 illustrates a considerable improvement in model behavior from the run in Figure 4.12. In both runs, the fall of quality due to the exogenous input pulls the engineer's total evaluation below average. The pressure exerted by the company to increase performance again produces an atmosphere of competition. The company reacts by attempting to encourage more cooperation. However as performance falls, the engineer decreases his interaction even more, mainly because he must work very intensely to keep his job. By the time the company policy takes effect it no longer uses enough effect to keep interaction from decreasing again. Management now increases
its program to induce greater cooperation and after a very long time, 140 months, the situation finally stabilizes. The fact that management continually underestimated the individual's desire to decrease interaction can be attributed to the time delays necessary to observe the situation and take action. Nevertheless interaction never gets below a value of 3 and the entire model does not behave too badly considering the engineer has below average capabilities.

The revised model is now tested on an engineer who initially does below average work, but after five years recovers his lost ground. The simulation is presented in Figure 5.12. Initially quality falls and then recovers because of the exogenous input. But after 60 months the prospects for the engineer look excellent. His evaluation is above average, he is cooperating, and he uses his time efficiently. As interaction increases because of new rewards, the company exerts pressure to keep this interaction from getting out of hand. Unfortunately the company exerts too much pressure and the individual starts to compete once more. By the 80th month cooperation is below average and the company embarks on a program to increase interaction. By the 92nd month management's policies prove successful and interaction is better than average. Evaluation is also above normal, the employee starts to be motivated by rewards and in the 100th month the situation again looks promising. But loops 8 and 9, discussed in Chapter 4 continue attempting to force interaction still higher. The company responds by attempting to limit interaction once more. The behavior of the model becomes more
and more unstable and indeed the situation is explosive. An investigation into the causes of this instability reveal the following. Loops 8 and 9 tend to perpetuate any change in interaction. If management tries to increase interaction even slightly, this change gets reinforced. Interaction overshoots management's desires and the situation must be corrected. But again the model overshoots desired interaction. Thus company induced interaction represented by letter I in the model is continually out-of-phase with N or actual interaction. The time delay, with which they are out-of-phase, is the time it takes to observe the situation, implement corrective actions, and have these actions take effect.

These last four runs provide insight into the advantages and disadvantages of the revised model. It appears that this revised model is successful when the system is not changing too rapidly. It is especially successful when trying to discourage interaction as the time delays are extremely short in implementing a policy to accomplish this.

However, the revised model has one serious disadvantage. Fluctuations in interaction are caused by changes in an individual's motivation to interact. The revised model does not try to effect this motivation. For example, an above average engineer, who is highly rewarded, has a tendency to want to goof-off. Management does not try to change this tendency. It simply warns the individual not to goof-off. The desire is still there, nevertheless. Nothing has been done to curb it. If at any time management relaxes its policy of limiting interaction, the engineer will take advantage of this relaxation and engage in non task-
oriented activities. There is a constant conflict between management's desires and those of the individual. This conflict can be kept under control unless the individual's motivation to interact starts increasing very rapidly. If this occurs, the situation becomes unstable. The case just discussed can be illustrated. Consider the run in Figure 5.13. It represents the response of the revised model to an input simulating an above average engineer. In addition the evaluation policy is weighted heavily toward high quality contract work, and thus emphasizes his advantages. The result of a highly rewarded engineer who would want to goof-off a little if he were allowed to do so. Management must constantly struggle to limit his interaction. Indeed, they are reasonably successful until the 120th month. At this time, the extremely rapid increases in the individual's natural desire to interact occur faster than changes in company pressure to contain interaction. The situation becomes explosive. The control policies used in the revised model can no longer cope with the situation.

The situation can also be reversed. Consider the individual who initially is forced to work mostly by himself because he does not meet company expectations. His natural motivation is to compete in order to retain his job. The company continually must encourage interaction. Here the problem is even more troublesome because of the longer time delays necessary in effectively introducing a program to encourage cooperation.

An illustration of this problem is presented in Figure 5.14. The input represents an engineer who initially falls behind in technical
Figure 5.13 Revised Model - Above Average Engineer Emphasis on Quality

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Figure 5.14 Revised Model - Engineer Recovers
Initial Deficiencies, Emphasis on Quality
competence and decides he must compete in order to remain employed. Again the evaluation policy is heavily weighted in favor of high quality contract work. This emphasizes this engineer's initial deficiencies even more. The behavior of the model is clearly unstable. The company spends most of its efforts attempting to encourage cooperation. But when they are successful, as they are in the 140th and 100th month for example, trouble still develops. The company must now change its policies quickly in order to prevent this increased interaction from leading to inefficiency and low productivity.

These last two simulation runs illustrate the difficulties the company runs into by trying to influence an individual's interaction without producing any effect on his natural desires to interact. This policy is like trying to keep a lid on a boiling kettle in order to prevent the water from spilling out. If the water is boiling only gently, this idea is successful. However, as the water boils more turbulently the lid can be blown off and becomes useless. In the same way trying to control interaction by enforcing an artificial atmosphere upon the employees may work if the employees' motivational desires are not strong, but when they get out of hand as they did in the last two runs this policy does not work. To control the interaction you must influence the individual's motivation to interact.

The final simulation is illustrated in Figure 5.15. It is at attempt to once more see the effect of monthly staff meetings designed to keep the employees fully appraised of the standards the company is using to evaluate them. The simulated run is the revised model with an
Figure 5.15 Revised Model - Above Average Engineer Emphasis on Quality, Monthly Staff Meetings
input representing an above average engineer. Again the evaluation is weighted to emphasize quality of contract work. The effect of the monthly staff meetings can be investigated by comparing this run with the run of Figure 5.13. System behavior remains essentially the same. The only difference is in the extent of the fluctuations of the key parameters. It appears that reducing the time it takes an engineer to perceive how he is evaluated increases the instability of the model. An explanation for this behavior is that the system is basically unstable. Long term averages tend to smooth out these variations. Shorter time averages tend to fluctuate as much as the quantity they are trying to average. Thus in a basically unstable system longer time delays in the smoothing equation tend to have a controlling influence on the model, whereas short delays do not limit these fluctuations to any extent.
CHAPTER 6

SUMMARY AND CONCLUSIONS

Professional performance depends on group and individual efforts. A typical company appraisal-incentive policy not only affects the individual staff member's motivation to work, it also affects the individual's motivation to interact and cooperate with the other professionals on the technical staff. Management often ignores the unintended implications of this policy of interaction, somehow assuming that "natural forces" will prevent excessively high interaction or excessively low interaction. High interaction implies an informal, casual atmosphere in which employees are constantly communicating and cooperating. Carried to an extreme, however, high interaction leads to costly inefficiency and low productivity. Too much time is spent on non-task oriented activities such as bull sessions, coffee breaks, etc., all of which decrease the professional technical person's effectiveness. Low interaction, on the other hand, implies a formal business atmosphere. If uncontrolled it leads to a situation of little social communication, an unwillingness to share technical knowledge, poor group cohesiveness, an a general attitude of competition. Each individual strives to out perform his colleagues in order to achieve higher performance ratings.
In order to find out if these "natural forces" really exist, a complicated feedback system relating the important variables was constructed. The model was then simulated on a digital computer. Two important results were determined by observing model behavior. First, if an employee perceives that he has below average capabilities his performance is motivated primarily by his fear of losing his job. Security is his desired goal. As a result he is constantly striving for higher performance ratings. He does not have the time nor the inclination to interact. He cooperates only when asked to do so, but not voluntarily on his own time. Once he starts competing, there appears to be no natural force or pressure which makes him more cooperative. He identifies with groups and organizations outside the company, rather than the project teams with which he is associated. An atmosphere of competition once established in a company does not tend to correct itself. This is illustrated in Figure 4.12. Staff members just don't get together and decide to cooperate all of a sudden. Although individual competitive striving may spur productivity in some companies, this is not true in the knowledge industry. The flow of ideas and information and the cohesiveness of project teams are vital if the company wishes to keep pace with the rapid changes of technology and produce high quality contract work.

Second, an employee who perceives that he is above average and is therefore receiving high rewards does not work to full capacity. He
tends to goof-off. He has essentially satisfied his desire for security, prestige, etc., and is motivated at this point more by the approval and acceptance of his colleagues rather than by increased rewards. As the company notices the lapses in performance due to his inefficient use of time, management pressures him to improve his performance. This pressure forces him to use his time more effectively and as a result his productivity improves. The company relaxes its pressure and the individual starts goofing off again. The process continues until an equilibrium is established in which the individual is interacting as much as possible without lowering his performance below company expectations. Because the company is satisfied with his performance it is unaware that this employee can be stimulated to much higher rates of productivity. Thus the equilibrium is stable. Figure 4.10 illustrates this type of model behavior.

In order to correct these situations a revised system is introduced. In this system management is very much concerned with the extent of a staff member's interaction. The new model allows the company to observe social interaction and compare it to a desired level of interaction. The company now has a second form of control over professional performance. If the employee is interacting too strongly the company attempts to limit this interaction. It does so by a variety of schemes. Some are direct, such as discouraging social conversation, staff get-togethers or bull sessions. Others are indirect, such as locating desks in a manner not conducive to socializing or dividing contract work so as to
prevent the need for much interaction. If an employee is not interacting as much as the company would prefer, management embarks on a policy to increase interaction. This type of policy is assumed to be harder to implement. Thus it takes a longer time before its effects become apparent than does a policy designed to decrease interaction.

The revised model is now run on a computer. The results indicate, as in Figures 5.2 and 5.4, that the addition of this second form of control over a staff member's performance is very helpful in improving overall system behavior. The wide fluctuations in interaction, observable in Figures 4.12 and 4.13 are significantly decreased or eliminated all together. Individuals perform up to their capabilities and as a result, not only do they receive higher rewards, the company's rate of growth is improved.

However, the revised policy has one serious disadvantage. This disadvantage stems from the fact that the company programs to control interaction are in a sense artificial. They don't attack the origin of the problem; namely, the individual's natural desires and motivations to interact. For example, a highly rewarded employee who wants to goof-off is told not to. The desire is still there. There is a conflict between management's desires and those of the individual. Problems develop when changes in the employee's motivation to interact, increase or decrease more rapidly than the company can institute new policies to counteract these changes. In fact due to delays in observing interaction, implementing new policies, and having them take effect, company policy
becomes out-of-phase with individual motivation and an unstable, explosive situation can develop as illustrated in Figures 5.13 and 5.14.

This thesis does not attempt to find a solution to the problem just presented. The simulations provide graphic evidence of what could happen in a company when this situation is viewed from a system analyst's point of view. One suggestion for further study would be to see the effect of evaluating interaction in the same way quality is evaluated and provide incentives on the basis of this evaluation. Care should be taken however because any policy which attempts to regulate the means to improved performance, rather than performance itself, might prove to be dangerous and self-defeating. For example, some employees simply cannot get along with others and left to themselves will be extremely productive. If forced to interact they might be much less efficient and perform less useful work.

Many companies in the knowledge industry are interested in rapid expansion. They emphasize proposal work as a means of securing contract awards. Even with a large backlog of contract work, a staff member may be asked to devote much of his time to writing proposals. It was suggested that if the company relaxed this constant pressure to turn out proposals and allowed the employee to devote most of his efforts to producing sound quality contract work, it would in the long run produce stronger motivation for the individual and be more conducive to company goals of expansion and growth. A comparison of Figures 5.2 with 4.10
and 5.4 with 4.12 reveal the effect of placing more emphasis on quality contract work. An above average engineer is more strongly motivated and is more productive under an evaluation which emphasizes quality, because his superior qualities are amplified. However, engineers who are not as capable are penalized by the fact that their deficiencies are emphasized. Their evaluation is lower and they are less motivated. The conclusion seems to indicate that employees should be encouraged to engage in activities which they are best suited for, and which will allow them to obtain the highest evaluation they can possibly achieve. This is the best policy from a motivation-oriented point of view.

Curiously most research organizations are market-oriented. They feel that the best engineers should write proposals. In this way, they hope to secure more contract awards. It is not clear whether or not in the long run, this is a better policy. Much can be said for the advantages attributable to a favorable company reputation for high quality contract work, and increased satisfaction and higher motivation of the staff member in the company. These may prove to be a firmer foundation on which to base company goals.

Finally, it was suggested that companies often do not stimulate communication between management and the employee as to the standards used in the evaluation process. The need for personal attention from management is essential in providing proper guidance for the staff member's efforts. For example, an employee may feel that his evaluation
depends on how successful he is in completing a particular contract on time, whereas the company is more concerned with his efforts to solicit another contract from the same customer. In order to properly guide the engineer's efforts a monthly meeting between management and the staff is proposed. To implement this change in the model, the delay for the employee's perception of the standards by which he is evaluated is reduced from an average of the actual standards over 24 months to an average over one month. A comparison of the run in Figure 5.4 to the run in Figure 4.10 indicates that in a fairly stable company atmosphere, this change has little effect. An average over 24 months is the same as an average over one month and the employee is fairly well guided simply by past experience. However, in a basically unstable situation such as pictured in Figure 5.13 and 5.15 the effect of this change is to make the fluctuations even more pronounced. This is because an average over 24 months smoothes out these fluctuations and has a settling effect on the system. A short time delay fluctuates as much as the quantity it is attempting to average.

It is concluded that if the only purpose of these monthly staff meetings is to inform the engineer how he is being evaluated, they aren't worth the effort. If they also provide for better management employee relations they might be very important. Perhaps a revised model including a variable representing the employee's motivation derived from satisfaction with supervision should be constructed.
NOTE MODEL FOR APPRAISAL INCENTIVE POLICY
NOTE MOTIVATION FROM INCENTIVES
NOTE A1 SALARY
58A MSI*K=TABHL(TMSI*SIRE*K,0255)
NOTE MOTIVATION FROM SALARY INCREASE
C TMSI*=.8/1/1/2/1.4/1.5
NOTE TABLE, MOTIVATION FROM SALARY INCREASE
20A SIRE*K=SI*JK/ESI*K
NOTE SALARY INCREASE RELATIVE TO EXPECTED
3L ESI*K=ESI*J+(DT1/DAS)(SI*JK-ESI*J)
NOTE EXPECTED SALARY INCREASE
6N ESI=90
C DAS=24 MONTHS
NOTE DELAY TO ASSESS SALARY
12A MS*K=(MS*K)(MSM*K)
NOTE MOTIVATION FROM SALARY
58A MSM*K=TABLE(TMSM*S*K,03000:10000)
NOTE MOTIVATION FROM SALARY, MULTIPLIER
C TMSM=1/1/95/85
NOTE TABLE, MOTIVATION FROM SALARY, MULTIPLIER

NOTE B) PROMOTIONS
58A MPI*K=TABLE(TMPI*PIRE*K,0255)
NOTE MOTIVATION FROM POSITION INCREASE
C TMPK=1/1/1/5/1.6/8
NOTE TABLE, MOTIVATION FROM POSITION INCREASE
20A PIRE*K=PI*JK/EP*K
NOTE POSITION INCREASE RELATIVE TO EXPECTED
3L EPI*K=EPI*J+(DT1/DAP)(PI*JK-EPI*J)
NOTE EXPECTED POSITION INCREASE
6N EPI=1
C DAP=36 MONTHS
NOTE DELAY TO ASSESS POSITION
12A RM*K=(MS*K)(MPI*K)
NOTE REWARD MOTIVATION
NOTE C) PRESSURE
3L MPP*K=MPP*J+(DT1/DMPP)(CMPP*JK-MPP*J)
NOTE MOTIVATION FROM PROPOSAL PRESSURE
6N MPP=1
C DMPP=2 MONTHS
NOTE DELAY TO MOTIVATE PROPOSAL PRESSURE
58R CMPP*K=TABLE(TCMPP*PPW*K,0355)
NOTE CHANGE IN MOTIVATION FROM PROPOSAL PRESSURE
C TCMPP=1/5/1/1.5/2/1.5/5
NOTE TABLE, CHANGE IN MOTIVATION FROM PROPOSAL PRESSURE
3L MCPP*K=MCPP*J+(DT1/DMCP)(CMCPP*JK-MCPP*J)
NOTE MOTIVATION FROM CONTRACT PRESSURE
6N MCP=1
C DMCP=5 MONTHS
NOTE DELAY TO MOTIVATE CONTRACT PRESSURE
58R CMCP*K=TABLE(TCMCP*PCW*K,0355)
NOTE CHANGE IN MOTIVATION FROM CONTRACT PRESSURE
NOTE TABLE: CHANGE IN MOTIVATION FROM CONTRACT PRESSURE
NOTE MOTIVATION FROM GROUP COHESION
NOTE 3L MGC*K=MGC*J+(DT)/(1/DMGC)(CMGC*JK-MGC*J)
NOTE MOTIVATION FROM GROUP COHESION
6N MGC=CMGC
C DMGC=2 MONTHS
NOTE DELAY TO MOTIVATE CHANGE IN GROUP COHESION
5BR CMGC*KL=TABLE*(MGC*GC*K*025)
NOTE CHANGE IN MOTIVATION FROM GROUP COHESION
C TCMGC*=57/1167/2
NOTE TABLE: DELAY TO MOTIVATE CHANGE IN GROUP COHESION
NOTE
NOTE MOTIVATION EFFECTS ON TECHNICAL PERFORMANCE
NOTE
NOTE 3L MIC*K=MIC*J+(DT)/(1/DIMC)(CMIC*JK-MIC*J)
NOTE MOTIVATION FROM INCENTIVES, CONTRACT WORK
6N MIC=CMIC
C DIMC=2 MONTHS
NOTE DELAY TO INDUCE MOTIVATION CHANGE
15R CMIC*KL=TABLE*(REM*K)(MIC*K)+(REM*K)(MCP*K)
NOTE CHANGE IN MOTIVATION FROM INCENTIVES, CONTRACT WORK
12A MIC*K=(FMIC*K)(RM*K)
NOTE MOTIVATION FROM REWARD INCENTIVES, CONTRACT WORK
58A REM*K=TABLE*(TREM*CE*K*9111)
NOTE REWARD EFFECT ON MOTIVATION
C TREM*=05/1
NOTE TABLE: REWARD EFFECT ON MOTIVATION
58A FMIC*K=TABLE*(TFMIC*CWF0*K*015)
NOTE FRACTION OF MOTIVATION FROM INCENTIVES, CONTRACT WORK
C TFMIC*=5/12
NOTE TABLE: FRACTION OF MOTIVATION FROM INCENTIVES
3L CWF0*K=CWF0*J+(DT)/(1/DOWF)(CWF*J-CWF0*J)
NOTE CONTRACT WEIGHTING FACTOR OBSERVED
6N CWF0=CWF
NOTE CONTRACT WEIGHTING FACTOR
C DOWF=24 MONTHS
NOTE DELAY TO OBSERVE WEIGHTING FACTOR
12A MFGC*K=(MCON)(MGC*K)
NOTE MOTIVATION FROM GROUP, CONTRACT WORK
C MCON=.75
NOTE CONSTANT: CONTRACT MOTIVATION
7A MCW*K=MIC*K+MFGC*K
NOTE MOTIVATION TO DO CONTRACT WORK
6N NMWC=MCW
NOTE NORMAL MOTIVATION TO DO CONTRACT WORK
NOTE
NOTE B) PROPOSAL WORK
3L MIP*K=MIP*J+(DT)/(1/DIMP)(CMIP*JK-MIP*J)
NOTE MOTIVATION FROM INCENTIVES, PROPOSAL WORK
6N MIP=CMIP
C DIMP=2 MONTHS
15R CMIP*KL=(REM*K)*(MRRP*K)+(PEM*K)*(MPR*K)
NOTE CHANGE IN MOTIVATION FROM INCENTIVES, PROPOSAL WORK
12A MRRP*K=(FMIP*K)*(RM*K)
NOTE MOTIVATION FROM REWARD INCENTIVES, PROPOSAL WORK
7A PEM*K=1-REM*K
NOTE PRESSURE EFFECT ON MOTIVATION
58A FMIP*K=TABLET(FMMIP*PWSFO*K*01*5)
NOTE FRACTION OF MOTIVATION FROM INCENTIVES, PROPOSAL WORK
C TFMIP*=0.5/1/2
NOTE TABLE* FRACTION OF MOTIVATION FROM INCENTIVES
7A PWFSO*K=1-CWFSO*K
NOTE PROPOSAL WEIGHTING FACTOR OBSERVED
12A MFGR*K=(MPRO)*MFCR*K
NOTE MOTIVATION FROM GROUP, PROPOSAL WORK
7N MPRO=1-MCON
NOTE CONSTANT, PROPOSAL MOTIVATION
7A MPW*K=MPR*K+MFGR*K
NOTE MOTIVATION TO DO PROPOSAL WORK
6N NMPW=MPW
NOTE NORMAL MOTIVATION TO DO PROPOSAL WORK
NOTE NOTE MOTIVATION TO INTERACT
NOTE NOTE
NOTE A) PRESSURE
58A EPI*K=TABLET(TEPI*K*MPR*K+1,2,3,2)
NOTE EFFECT OF PROPOSAL PRESSURE ON INTERACTION
C TEP*K=0/-02/-06/-1/-12/-3
NOTE TABLE, EFFECT OF PROPOSAL PRESSURE ON INTERACTION
58A ECR*K=TABLET(TECR*K*MCR*K+1,2,3,2)
NOTE EFFECT OF CONTRACT PRESSURE ON INTERACTION
C TECR*K=0/-02/-06/-1/-12/-3
NOTE TABLE, EFFECT OF CONTRACT PRESSURE ON INTERACTION
18A PEI*K=(MI*K)*(EPI*K+ECR*K)
NOTE PRESSURE EFFECT ON INTERACTION
NOTE NOTE
NOTE B) REWARD
51A RCC*K=CLIP(ERWC*K*ERNC*K*MGC*K+99)
NOTE REWARD, COHESION, CORRELATION
58A ERNC*K=TABLET(TERN*K*RM*K+1,2,3,2)
NOTE EFFECT OF REWARD, NO COHESION
C TERN*K=0/-01/-02/-05/-07/-01
NOTE TABLE, EFFECT OF REWARD, NO COHESION
58A ERWC*K=TABLET(TERWC*K*RM*K+1,2,3,2)
NOTE EFFECT OF REWARD, WITH COHESION
C TERWC*K=0/-01/-02/-02/-02/-02
NOTE TABLE, EFFECT OF REWARD, WITH COHESION
12A REI*K=(RCC*K)*(MIR*K)
NOTE REWARD EFFECT ON INTERACTION
NOTE NOTE
NOTE C) COHESION
58A EGC*K=TABLET(TEGC*K+0,2,3,5)
NOTE EFFECT OF GROUP COHESION
C TEGC=-04/-02/-01/-001/-02
NOTE TABLE, EFFECT OF GROUP COHESION
12A  CEK*(K(EGC+K(MI*(K)
NOTE COHESION EFFECT ON INTERACTION
NOTE 3L MI*(K=MJ*(J*(DT*(1/01M)*(CMI*(K+0)
NOTE MOTIVATION TO INTERACT
6N MI=MII
NOTE INITIAL MOTIVATION TO INTERACT
C MII=1
8R CMI*KL=PEI*K+REI*K+CEI*K
NOTE CHANGE IN MOTIVATION TO INTERACT
C DIM=3 MONTHS
NOTE DELAY TO INDUCE MOTIVATION
NOTE SOCIAL INTERACTION
NOTE 1L SIN*K=SIN*K*(DT*(CSIN*K+0)
NOTE SOCIAL INTERACTION
6N SIN=SINI
NOTE INITIAL SOCIAL INTERACTION
C SIN=5
12R CSIN*KL=(PCSIN*K)(SIN*K)
NOTE CHANGE IN SOCIAL INTERACTION
58A PCSIN*K=TABHL(TPSIN*MII*K+0+2*5)
NOTE PERCENT CHANGE IN SOCIAL INTERACTION
C TPSIN*=0.2/-0.1/0.0/0.5/-1
58R C*KL=TABHL(TC*SIN*K+0+1*2)
NOTE COMMUNICATION
C TC=0.5/0.125/0.75/1.25/1.75/2
NOTE TABLE COMMUNICATION
58A GC*K=TABHL(TGC*IN*K+0+2)
NOTE GROUP COHESION
C TGC=0.5/0.75/1.25/1.75/2
NOTE TABLE GROUP COHESION
NOTE QUALITY OF CONTRACT WORK
NOTE 15A QCW*K=(CTP*(TPC*K)+(CGE*(GEC*K)
NOTE QUALITY OF CONTRACT WORK
7N CGE=1-CTP
NOTE CONSTANT GROUP EXPERIENCE
C CTP=6
NOTE CONSTANT TECHNICAL PERFORMANCE
58A EUT*K=TABHL(TEUT*SIN*K+0+10,1)
NOTE EFFICIENT USE OF TIME
C TEUT=1/0.9/0.7/0.5/0.3/0.1
NOTE TABLE EFFICIENT USE OF TIME
46A TPC*K=(EUT*K*(TEC*K)(MCW*K)/((1)(1)(NMCW))
NOTE TECHNICAL PERFORMANCE ON CONTRACTS
6N TEC=1
7A TEC*K=TEC1*K+TEC2*K
47A TEC2*K=RAMP(-01*48)
47A TEC1*K=RAMP(-01+12)
3L GEC*K=GEJ*(DT*(1/DEG)(GCJ*GEC-J)
NOTE GROUP EFFECT ON CONTRACTS
6N GEC=GC
C DEG=2 MONTHS
NOTE DELAY FOR EFFORT OF GROUP
NOTE QUALITY OF PROPOSAL
NOTE 15A PW*K=(KNOWLD(ATK*K)+(EXP)(TPP*K)
NOTE PROPOSAL WORTH
C KNOWL=2
NOTE CONSTANT, TECHNICAL KNOWLEDGE
7N EXP=1-KNOWL
44A TPP*K=(MPW*K)(EUT*K)/NMPW
NOTE TECHNICAL PERFORMANCE ON PROPOSALS
3L ATK*K(ATK*J+(DT11/DUI)(C*JK-ATK*J)
NOTE AVAILABLE TECHNICAL KNOWLEDGE
6N ATK=C
C DUI=9 MONTHS
NOTE DELAY TO UTILIZE INFORMATION
NOTE NOTE CONTRACTS IN HOUSE
NOTE C AC=10 CONTRACTS
NOTE AVAILABLE CONTRACTS
58A FRR*K=TABHL(TFRR*APQCW*K+0.2*5)
NOTE FRACTION OF REQUESTS RECEIVED
C TFRR=0.05/0.08/0.28/0.3
NOTE TABLE: FRACTION OF REQUESTS RECEIVED
3L APQCW*K=APQCW*J+(DT)(1/DOQ)(QCW*J-APQCW*J)
NOTE AVERAGE PAST QUALITY OF CONTRACT WORK
6N APQCW=QCW
C DOQ=36 MONTHS
NOTE DELAY TO OBSERVE QUALITY
12R PRR*KL=(AC)(FRR*K)
NOTE PROPOSAL REQUESTS RECEIVED
20R PRA*KL=PRR*JK/DCP
NOTE PROPOSAL REQUESTS ANSWERED
C DCP=3 MONTHS
NOTE DELAY TO COMPLETE PROPOSAL
58A FCA*K=TABHL(TFCA*PP*K+0.2*5)
NOTE FRACTION OF CONTRACTS AWARDED
C TFCA=0.05/0.08/0.28/0.3
NOTE TABLE: FRACTION OF CONTRACTS AWARDED
1L CIH*K=CIH*J+(DT)(CCIH*JK+0)
NOTE CONTRACTS IN HOUSE
6N CIH=CIHI
NOTE INITIAL CONTRACTS IN HOUSE
C CIHI=2
7R CCIH*KL=CA*JK-CLC*JK
NOTE CHANGE IN CONTRACTS IN HOUSE
12R CA*KL=(PRA*JK)(FCA*K)
NOTE CONTRACTS AWARDED
20R CWC*KL=CIH*K/DCC
NOTE CONTRACT WORK COMPLETED
C DCC=12 MONTHS
NOTE DELAY TO COMPLETE CONTRACTS
NOTE
NOTE EVALUATION
NOTE A) CONTRACT WORK
20A ECw*K=OQw*K/DQw*K
NOTE EVALUATED CONTRACT WORK
3L OQw*K=OQw*J+(DT)(1/DQWJ)(QCw*J-OQw*J)
NOTE OBSERVED QUALITY OF WORK
6N OQW=QCW
C DQW=6 MONTHS
NOTE DELAY TO ASSESS QUALITY
3L DQW*K=DQW*J+(DT)(1/DQWJ)(IQD*J-DQW*J)
NOTE DESIRED QUALITY OF WORK
6N DQW=IQD
C DQD=8 MONTHS
58A IQD*=TABHL(TIQD*OQW*K*0*2*5)
NOTE INCREASE IN QUALITY DESIRED
C TIQD*=.5/751/1.25/1.5
NOTE TABLE* INCREASE IN QUALITY DESIRED
NOTE
NOTE B) PROPOSAL WORK
20A EPw*K=FCA*K/FCD*K
NOTE EVALUATED PROPOSAL WORTH
3L FCD*K=FCD*J+(DT)(1/DCDJ)(IFCD*J-FCD*J)
NOTE FRACTION OF CONTRACTS DESIRED
6N FCD=1FCD
C DCD=12 MONTHS
NOTE DELAY TO INCREASE CONTRACTS DESIRED
58A IFCD*K=TABLE*(TIFCD*FCA*K*0*3*1)
NOTE INCREASE IN FRACTION OF CONTRACTS DESIRED
C TIFCD*=.05/15/2/25
NOTE TABLE* INCREASE IN FRACTION OF CONTRACTS DESIRED
NOTE
NOTE C) EVALUATION
15A IEVAL*K=(CWF*K)(ECW*K)+(PWFK*K)(EPW*K)
NOTE INSTANTANEOUS EVALUATION
7A PWFK*K=1-CWF*K
NOTE PROPOSAL WEIGHTING FACTOR
58A CWF*K=TABLE*(TCWF*K*0*4*1)
C TCWF*=.00/25/.5/.75/1
NOTE TABLE* CONTRACT WEIGHTING FACTOR
3L CE*K=CE*KJ+(DT)(1/DEVAL)(IEVAL*K-CE*K)
NOTE COMPANY EVALUATION
6N CE=CEIN
NOTE INITIAL COMPANY EVALUATION
C CEIN=1
C DEVAL=6 MONTHS
NOTE DELAY TO EVALUATE
NOTE
NOTE INCENTIVES
NOTE A) SALARY
1L Sk=Sk+J+(DT)(S1*JK*0)
NOTE SALARY
6N S=15
NOTE INITIAL, SALARY
C IS=8000 DOLLARS
12R SI*KL=(PSI*K)(ESI*K)
NOTE SALARY INCREASE
58A PSI*K=TABHL(TPSI*CE*K+0*2*5)
NOTE PERCENT SALARY INCREASE
C TPSI#=0/0/0/1,1,75/2*5
NOTE TABLE, PERCENT SALARY INCREASE
NOTE
A NOTE
B) PROMOTION
1L PC*K=PC*J+(DT)(PI*JK+0)
NOTE POSITION IN COMPANY
6N PC=PCI
NOTE INITIAL, POSITION IN COMPANY
C PCI=1
12R PI*KL=(PPI*K)(EPI*K)
NOTE POSITION INCREASE
58A PPI*K=TABHL(TPPI*CE*K+0*2*5)
NOTE PERCENT POSITION INCREASE
C TPPI#=0/0/0/1,1,5/2*5
NOTE TABLE, PERCENT POSITION INCREASE
NOTE
NOTE
C) PRESSURE
58A PPW*K=TABHL(TPW*EPW*K+J*2*5)
NOTE PRESSURE TO IMPROVE PROPOSAL WORK
C TPPW#=3/2/1/1,25/0
NOTE TABLE, PRESSURE TO IMPROVE PROPOSAL WORK
58A PW*K=TABHL(TPCW*ECW*K+0*2*5)
NOTE PRESSURE TO IMPROVE CONTRACT WORK
C TPCW#=3/2/1/1,25/0
NOTE
PRINT 11MS*MPI*RM*MPP,MCP
PRINT 22MG*CIC*MIC*MRIC*CWF,CWFO
PRINT 31MCW*MIP*MRIP*MPW*EPPI
PRINT 41ECPI*PEI*RCC*ERNC*ERWC
PRINT 51REI*EGC*CEI*CMI*MI
PRINT 61SIN*CSIN*GcGC*TPC
PRINT 71GEC*ETC*PW*TPP
PRINT 81ATK*FRR*APC*CWC*FCM*CIH
PRINT 91CCIC*CA*CE*5*SI
PRINT 101ECW*QW*DQW*EPW*FCD
PRINT 111PC*PI*PPW*PCW
PLOT CE=E*MI=M*QKW=Q*PW=P(0,2)/S=S/CIH=C/SIN=N
SPEC DT=25/LENGTH=200/PRTPER=4/PLTPER=2
RUN 502B
C TCWF#=0/5/1/1/1/
C TCMCP=+.5/75/1/5/2/1/5/5
TCMCP TABLE; CHANGE IN MOTIVATION FROM CONTRACT PRESSURE
NOTE
NOTE MOTIVATION FROM GROUP COHESION
NOTE
2L MGC=K=MGC+J+(DT)/1/DMGC)(CMGC-JK-MGC-J)
C MGC MOTIVATION FROM GROUP COHESION
6N MGC=CMGC
C DMGC=2 MONTHS
DMGC DELAY TO MOTIVATE CHANGE IN GROUP COHESION
5BR CMGC=KL=(TCMGCGC)K*0*2*5
CMGC CHANGE IN MOTIVATION FROM GROUP COHESION
C TCMGC=+.5/7/1/1/7/2
TCMG TABLE; DELAY TO MOTIVATE CHANGE IN GROUP COHESION
NOTE
NOTE MOTIVATION EFFECTS ON TECHNICAL PERFORMANCE
NOTE
NOTE A) CONTRACT WORK
3L MIC=K=MIC+J+(DT)/1/DMIC)(CMIC-JK-MIC-J)
MIC MOTIVATION FROM INCENTIVES; CONTRACT WORK
6N MIC=CMIC
C DMIC=2 MONTHS
DMIC DELAY TO INDUCE MOTIVATION CHANGE
15R CMIC=KL=(REM*K)(MRIC*K)+(PEM*K)(MCP*K)
CMIC CHANGE IN MOTIVATION FROM INCENTIVES; CONTRACT WORK
12A MRIC=IC=(FMIC*K)(RM*K)
MRIC MOTIVATION FROM REWARD INCENTIVES; CONTRACT WORK
5BA REM=K=TABLE(REW*K+9*1/1)*1)
REM REWARD EFFECT ON MOTIVATION
C TREM=+.5/6/1
TREM TABLE; REWARD EFFECT ON MOTIVATION
5BA FMIC=K=TABLE(FMIC*CWFO=K+0*3*5)
FMIC FRACTION OF MOTIVATION FROM INCENTIVES; CONTRACT WORK
C TFMIC=+.5/1/2
TFMIC TABLE; FRACTION OF MOTIVATION FROM INCENTIVES
5L CWFO=K=CWFO+J+(DT)/1/DWFO(CWFJ-CWFO*J)
CWFO CONTRACT WEIGHTING FACTOR OBSERVED
6N CWFO=CWF
C DWFO=24 MONTHS
DOWF DELAY TO OBSERVE WEIGHTING FACTOR
12A MFGC=K=(MCON)IGMC*K)
MFGC MOTIVATION FROM GROUP; CONTRACT WORK
C MCON=+.75
MCON CONSTANT; CONTRACT MOTIVATION
7A MCG=K=MIC*K+MFGC*K
MCW MOTIVATION TO DO CONTRACT WORK
6N MCW=MCW
MCW NORMAL MOTIVATION TO DO CONTRACT WORK
NOTE
NOTE B) PROPOSAL WORK
3L MIP=K=MIP+J+(DT)(1/DIMP)(CMIP-JK-MIP-J)
MIP MOTIVATION FROM INCENTIVES; PROPOSAL WORK
6N MIP=CMIP
C DIMP=2 MONTHS
15R  CMIP,K=(REM,K)(MRIPT,K)+(PEM,K)(MPP)
CMIP  CHANGE IN MOTIVATION FROM INCENTIVES, PROPOSAL WORK
12A  MRIPT,K=(FMIP,K)(RMK)
MRIPT MOTIVATION FROM REWARD INCENTIVES, PROPOSAL WORK
7A  PEM,K=1-REM,K
PEM PRESSURE EFFECT ON MOTIVATION
58A  FMIP,K=Tabhl(FMIP*PWFO,K*0.1*0.5)
FMIP FRACTION OF MOTIVATION FROM INCENTIVES, PROPOSAL WORK
C  TFMIP=5/1/2
TFMIP TABLE, FRACTION OF MOTIVATION FROM INCENTIVES
7A  PWFO,K=1-CWFO,K
PWFO PROPOSAL WEIGHTING FACTOR OBSERVED
12A  MFGP,K=(MPRO)(MGC,K)
MFGP MOTIVATION FROM GROUP, PROPOSAL WORK
7N  MPRO=1-MCON
MPRO CONSTANT, PROPOSAL MOTIVATION
7A  MPW,M=FIP.K+MFGP,K
MPW MOTIVATION TO DO PROPOSAL WORK
6N  NMPW=MPW
NMPW NORMAL MOTIVATION TO DO PROPOSAL WORK
NOTE NOTE NOTE TO INTERACT
NOTE NOTE NOTE TO INTERACT
NOTE A) PRESSURE
58A  EPPK=Tabhl(TEPPI+MPP*8*2*2)
EPPK EFFECT OF PROPOSAL PRESSURE ON INTERACTION
C  TEPPI=0/0/-0.02/-0.06/-0.1/-0.2/-0.3
TEPPI TABLE, EFFECT OF PROPOSAL PRESSURE ON INTERACTION
58A  ECPK=Tabhl(TECPI+MPC*8*2*2)
ECPK EFFECT OF CONTRACT PRESSURE ON INTERACTION
C  TECPI=0/0/-0.02/-0.06/-0.1/-0.2/-0.3
TECPI TABLE, EFFECT OF CONTRACT PRESSURE ON INTERACTION
18A  REIK=(MI*K)(EPPK+ECPI*K)
REI PRESSURE EFFECT ON INTERACTION
NOTE NOTE NOTE
NOTE B) REWARD
51A  RCCK=CLIP(ERNCK*ERNCK+MGC,K*99)
RCCK REWARD, COHESION, CORRELATION
58A  ERNCK=Tabhl(ERNCK+RMK*8*2*2)
ERNK EFFECT OF REWARD, NO COHESION
C  TERNC=0/0/-0.01/-0.02/-0.05/-0.07/-0.1
TERNC TABLE, EFFECT OF REWARD, NO COHESION
58A  ERNCK=Tabhl(ERNCR+RMK*8*2*2)
ERNK EFFECT OF REWARD, WITH COHESION
C  TERNC=0/0/-0.01/-0.02/-0.02/-0.02/-0.02
TERNC TABLE, EFFECT OF REWARD, WITH COHESION
12A  REIK=(RCCK)(MI*K)
REI REWARD EFFECT ON INTERACTION
NOTE NOTE NOTE
NOTE C) COHESION
58A  EGCK=Tabhl(TEGC*GCK*0.2*0.5)
EGCK EFFECT OF GROUP COHESION
C  TEGC=-0.04/-0.02/0/0.01/0.02
TEGC TABLE, EFFECT OF GROUP COHESION
12A  CEIK=(EGCK)(MI*K)
CEI  COHESION EFFECT ON INTERACTION
NOTE
3L  MI*K=MI*J+(DT)(1/DIMI)(CMI*JK+O)
MI  MOTIVATION TO INTERACT
6N  MI=MII
MII  INITIAL MOTIVATION TO INTERACT
C  MII=I
BR  CMI*KL=PE1*K+RE1*K+CEI*K
CMI  CHANGE IN MOTIVATION TO INTERACT
C  DIM=2 MONTHS
DIM  DELAY TO INDUCE MOTIVATION
NOTE
NOTE  MANAGEMENT INDUCED MOTIVATION TO INTERACT
NOTE
3L  MIN*K=MIN*J+(DT)(1/DIMI)(EMIN*J-MMIN*J)
MMIN  MOTIVATION FOR MORE INTERACTION
6N  MMIN=0
C  DMN=12 MONTHS
DMN  DELAY FOR MORE INTERACTION
3L  MLIN*K=MLIN*J+(DT)(1/DLIN)(PLIN*J-MLIN*J)
MLN  MOTIVATION FOR LESS INTERACTION
6N  MLN=0
C  DLIN=3 MONTHS
DLIN  DELAY FOR LESS INTERACTION
7A  IMIN*K=MIN*K-MLIN*K
IMIN  INDUCED MOTIVATION TO INTERACT
7A  IMEP*K=1-IMIN*K
IMEP  INDUCED MOTIVATION EFFECT ON PERFORMANCE
NOTE
NOTE  SOCIAL INTERACTION
NOTE
3L  SIN*K=SIN*J+(DT)(CSIN*JK+O)
SIN  SOCIAL INTERACTION
6N  SIN=SIN
SIN  INITIAL SOCIAL INTERACTION
C  SINI=5
1BR  CSIN*KL=(SIN*K)(PCSIN*K+ICSIN*K)
CSIN  CHANGE IN SOCIAL INTERACTION
5SA  ICSIN*K=TABHL(TCSIN*K+15*K+0)*2
ICIN  INDUCED CHANGE IN SOCIAL INTERACTION
C  TCSIN*K=-3/-25/-15/-15/-25/-3
TCSIN  TABLE, INDUCED CHANGE IN SOCIAL INTERACTION
5SA  PCSIN*K=TABHL(TPSIN*MII*K+O)*2
PCSIN  PER CENT CHANGE IN SOCIAL INTERACTION
C  TPSIN*=-2/-1/0/1/2/1
5BR  C*KL=TABHL(TC*SIN*K+0*1+2)
C  COMMUNICATION
C  TC*0/5/75/1/25/1/75/2
TC  TABLE, COMMUNICATION
5SA  GC*K=TABHL(TGC*SIN*K+0*1+2)
GC  GROUP COHESION
C  TGC*0/5/75/1/25/1/75/2
TGC  TABLE, GROUP COHESION
NOTE
NOTE  QUALITY OF CONTRACT WORK
NOTE
QC\textsubscript{K}=\{CT\}\{TPC\}\{CGE\}\{GEC\}  
QC\textsubscript{W} QUALITY OF CONTRACT WORK  
7N CGE=1-CTP  
CGE CONSTANT, GROUP EXPERIENCE  
C CTP=6  
CTP CONSTANT, TECHNICAL PERFORMANCE  
58A EUT\textscript{K}=\text{TABHLEUTSINK}*5*10*1  
EUT EFFICIENT USE OF TIME  
C TEUT\textscript{K}=1*/9*/7*/5*/3*/1  
TEUT TABLE, EFFICIENT USE OF TIME  
12A UT\textscript{K}=\{IMEP\}\{EU\textscript{K}\}  
UT USABLE TIME  
46A TPC\textscript{K}=\{UT\}\{KD\}\{TEC\}\{MWC\}\{NMWC\}  
TPC TECHNICAL PERFORMANCE ON CONTRACTS  
7A TEC\textscript{K}=TEC1\textscript{K}+TEC2\textscript{K}  
N TEC1=1  
47A TEC1\textscript{K}=\text{RAMP}\{01\}12  
47A TEC2\textscript{K}=\text{RAMP}\{-01\}48  
3L GEC\textscript{K}=GEC\textscript{J}+(DT):1/DEG\{GC\textscript{J}=GEC\textscript{J}\}  
GEC GROUP EFFECT ON CONTRACTS  
6N GEC=GC  
C DEG=2 MONTHS  
DEG DELAY FOR EFFORT OF GROUP  
NOTE QUALITY OF PROPOSAL  
NOTE KNOWL CONSTANT, TECHNICAL KNOWLEDGE  
7N EXP=1-KNOWL  
44A TPP\textscript{K}=\{MPW\}\{UT\}\{K\}  
TPP TECHNICAL PERFORMANCE ON PROPOSALS  
3L ATK\textscript{K}=ATK\textscript{J}+(DT):1/DUI\{C\textscript{JK}=ATK\textscript{J}\}  
ATK AVAILABLE TECHNICAL KNOWLEDGE  
6N ATK=C  
C DUI=9 MONTHS  
DUI DELAY TO UTILIZE INFORMATION  
NOTE CONTRACTS IN HOUSE  
NOTE AC=10 CONTRACTS  
AC AVAILABLE CONTRACTS  
58A FRR\textscript{K}=\text{TABHLE}(FRR\textscript{K}APQCW*100*0*5)  
FRR FRACTION OF REQUESTS RECEIVED  
C FRR\textscript{K}=0*/9*/8*/2*/28*/3  
FRRR TABLE, FRACTION OF REQUESTS RECEIVED  
3L APQCW\textscript{K}=APQCW\textscript{J}+(DT):1/DOQ\{QCW\textscript{J}=APQCW\textscript{J}\}  
APQCW AVERAGE PAST QUALITY OF CONTRACT WORK  
6N APQCW=QCW  
C DOQ=36 MONTHS  
DOQ DELAY TO OBSERVE QUALITY  
12R PRR\textscript{KL}=\{AC\}\{FRR\textscript{K}\}  
PRR PROPOSAL REQUESTS RECEIVED  
20R PRA\textscript{KL}=PRR\textscript{JK}/DCP
PRA PROPOSAL REQUESTS ANSWERED
C DCP=3 MONTHS
DCP DELAY TO COMPLETE PROPOSAL
5BA FCA.K=TABHL(TFCA*PW.K*.05/0.2/0.26/0.3)
FCA FRACTION OF CONTRACTS AWARDED
C TFCA=05/08/2/26/3
TFCA TABLE, FRACTION OF CONTRACTS AWARDED
1L CIH.K=CIH.J+(DT)(CCIH.JK+0)
CIN CONTRACTS IN HOUSE
6N CIH=CIH1
CIMI INITIAL CONTRATS IN HOUSE
C CIHI=2
7R CCIH.K=CA.JK=CWC.KJ
CCIH CHANGE IN CONTRACTS IN HOUSE
12R CA.KL=(PRA.K)(FCA.K)
CA CONTRACTS AWARDED
20R CWC.KL=CIH.K/DCC
CWC CONTRACT WORK COMPLETED
C DCC=12 MONTHS
DCC DELAY TO COMPLETE CONTRACTS
NOTE NOTE
NOTE A) CONTRACT WORK
20A ECW.K=QQW.K/DQW.K
ECW EVALUATED CONTRACT WORK
3L QQW.K=QQW.J+(DT)(1/DQU)(QCW.J-QQW.J)
QQW OBSERVED QUALITY OF WORK
6N QQW=QCW
C DQU=6 MONTHS
DQU DELAY TO ASSESS QUALITY
3L DQW.K=DQW.J+(DT)(1/DQD)(1/QQD.J-DQW.J)
DQW DESIRED QUALITY OF WORK
6N DQW=IQD
C DQD=8 MONTHS
58A IQD.K=TABHL(TIQD+QQW.K*.02/5)
IQD INCREASE IN QUALITY DESIRED
C TIQD=05/075/1/.25/1.5
TIQD TABLE, INCREASE IN QUALITY DESIRED
NOTE NOTE
NOTE B) PROPOSAL WORK
20A EPW.K=FCA.K/FCD.K
EPW EVALUATED PROPOSAL WORK
3L FCD.K=FCD.J+(DT)(1/DCD)(IFCD.J+FCD.J)
FCD FRACTION OF CONTRACTS DESIRED
6N FCD=IFCD
C DCD=12 MONTHS
DCD DELAY TO INCREASE CONTRACTS DESIRED
58A IFCD.K=TABHL(TIFCD.FCA.K*.03/1)
IFCD INCREASE IN FRACTION OF CONTRACTS DESIRED
C TIFCD=05/.15/2/25
TIFCD TABLE, INCREASE IN FRACTION OF CONTRACTS DESIRED
NOTE NOTE
NOTE C) SOCIAL ATMOSPHERE
3L OSIN.K=OSIN.J+(DT)(1/DOIN)(SIN.J-OSIN.J)
OSIN OBSERVED SOCIAL INTERACTION
6N OSIN=Sin
C DOIN=6 MONTHS
DOIN DELAY TO OBSERVE INTERACTION
20A EVIN*K=OSIN*K/DSIN
EVIN EVALUATION OF INTERACTION
C DSIN=5
DSIN DESIRED INTERACTION
NOTE
NOTE C) EVALUATION
15A IEVAL*K=(CWF*K)+(ECW*K)+(PWF*K)+(EPW*K)
IEVAL INSTANTANEOUS EVALUATION
7A PWK*K=1-CWF*K
PWF PROPOSAL WEIGHTING FACTOR
5BA CWF*K=TABHL(TCWFK*CIH*K+0*4+1)
CWF CONTRACT WEIGHTING FACTOR
C TCWF*=0/25/5/75/1
TCWF TABLE, CONTRACT WEIGHTING FACTOR
3L CE*K=CE*J+(DT/(1/DEVAL))\(1/IEVAL*J-CE*J)
CE COMPANY EVALUATION
6N CE=CEIN
CEIN INITIAL COMPANY EVALUATION
C CEIN=1
C DEVAL=6 MONTHS
DEVAL DELAY TO EVALUATE
51A EINT*K=CLIP(EVIN*K+1,OSIN*K+POLY)
EINT EVALUATED INTERACTION
C POLY=-1
NOTE
NOTE NOTE INCENTIVES
NOTE A) SALARY
1L S*K=S*J+(DT)/(S*IJK+0)
S SALARY
6N S=IS
IS INITIAL SALARY
C IS=8000 DOLLARS
12R SI*KL=(PSI*K)*(ESI*K)
SI SALARY INCREASE
5BA PSI*K=TABHL(TPSI,K*CE,K+0*2,5)
PSI PER CENT SALARY INCREASE
C TPSI*=0/0/1/1,75/2,5
TPSI TABLE, PER CENT SALARY INCREASE
NOTE
NOTE B) PROMOTION
1L PCI*K=PCI*J+(DT)/(PCI*JK+0)
PCI POSITION IN COMPANY
6N PCI=PCI
PCI INITIAL POSITION IN COMPANY
C PCI=1
12R PI*KL=(PP*K)*(EPI*K)
PI POSITION INCREASE
5BA PPI*K=TABHL(TPPI*CL*K+0*4,5)
PPI PER CENT POSITION INCREASE=E
C TPPI*=0/0/1,5/2,5
TABLE: PER CENT POSITION INCREASE

NOTE

C1 PRESSURE
58A PPW*K=TABHL(TPPW*EPW*K+0*2*5)
PPW PRESSURE TO IMPROVE PROPOSAL WORK
C TPPW=3/2/1/25/0
TPPW TABLE: PRESSURE TO IMPROVE PROPOSAL WORK
58A PCW*K=TABHL(TPCW*ECW*K+0*2*5)
PCW PRESSURE TO IMPROVE CONTRACT WORK
C TPCW=3/2/1/25/0
TPCW TABLE: PRESSURE TO IMPROVE CONTRACT WORK

NOTE

D) INTERACTION
58A EMIN*K=TABHL(TEMIN:EINT*K+1*2)
EMIN ENCOURAGE MORE INTERACTION
C TEMIN=5/4/3/2/1/0
TEMIN TABLE: ENCOURAGE MORE INTERACTION
58A PLIN*K=TABHL(TPLIN:EINT*K+2*5)
PLIN PRESSURE TO LESSON INTERACTION
C TPLIN=0/1/2/3/4/5
PLLIN TABLE: PRESSURE TO LESSON INTERACTION

X1

SPEC DT=.25/LENGTH=260/PRTPER=4/PLTPER=2
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