

**THE POTENTIAL IMPACT OF INFORMATION TECHNOLOGY
IN THE CONSTRUCTION INDUSTRY**

by

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**B.S., Civil Engineering 1984
University of Kansas**

Submitted to the Sloan School of Management
in Partial Fulfillment of
the Requirements of the Degree of

MASTER OF SCIENCE IN MANAGEMENT

at the

Massachusetts Institute of Technology

May 1989

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ABSTRACT

The construction industry involves large, multibillion dollar firms with a substantial amount of work at remote international locations. These firms face problems of how to manage and control remote projects and are especially handicapped at the head office by a lack of information from the project site.

My contention is that the basic head office-project office relationship in large construction firms has not been changed dramatically by information technology. Projects operate autonomously from the head office with the project manager having ultimate control over operating decisions. With advances in information technology, there are real possibilities for changing this relationship in construction, either by causing greater centralization of decision making and staff or by enabling the head office to more closely monitor the decentralized activities at project offices.

The principal conclusion is that information technology will increase the monitoring capability of the head office, but will not significantly centralize either decision making or project management staff. Because of major interdependencies between labor, subcontractors, and equipment deliveries, management staff must be stationed at the project site. With these people already on site, there is no particular advantage for centralizing decision making, especially when some information is soft and difficult to transmit and be understood away from the project site.

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CHAPTER 1

INTRODUCTION

Background

For many years now a construction firm could be content with operating domestically. The home market, especially in the case of the United States, was large enough to accommodate growth. Some firms did acquire other foreign firms in order to operate in various countries, but always on a multi-domestic basis, i.e. the subsidiaries would operate essentially as independent entities, except for the transfer of profits to the parent firm.

Presently, many trends are emerging which are changing the demand and supply for construction projects throughout the world. These forces will create a need for construction firms to become global in order to compete. This implies that a project is designed in one country, labor taken from another, project management from another, financing from another, and perhaps constructing the project in yet another country. These activities can be physically removed from the firm's head office to take advantage of strengths inherent in a particular subsidiary or lower costs from operating in a particular country. Forces for decentralizing a firm's functions are beginning to arise on both the demand and supply sides.

Demand Side

In terms of demand, a trend is developing towards the rehabilitation and maintenance of infrastructure around the country. Most of the U.S. road and bridge system has already been built, so that

major expansions are not needed. What is needed are maintenance and rehabilitation projects which are for the most part small in scope and spread out through the U.S. Such small projects have up to now been the domain of the small contractor, but many risks are inherent in this type of firm. These firms must pay higher interest rates to obtain financing and higher fees to be bonded than for larger firms. This makes these projects, which already have low markups due to the competitive bidding process, even less profitable for the small firms and increases the chance of bankruptcy. A large firm on the other hand has many advantages such as better technical expertise and ability to obtain financing at lower cost, but it cannot operate profitably on small projects because of its high overhead. With the advent of these small jobs, it will be necessary for large firms to use some sort of franchising technique to capture these jobs. This would entail the large firm using the small firms to do the actual work while the large firm provides the technical support and financing. This trend towards smaller projects will cause large U.S. firms to decentralize many of its functions. Foreign firms could also do this in the U.S. and start to globalize its operations.

The declining rate of growth in mega projects is also affecting demand. This translates into more intensive competition for the remaining projects, as well as forcing firms to develop new markets in order to stay viable.

Another change in demand is the move towards including trade in services under the General Agreement on Tariffs and Trade. This would increase the mobility of labor services and result in foreign construction firms becoming more competitive in the developing

world by being able to bring in their own labor force for particular projects.

Supply Side

In terms of supply, there is a trend among governments and owners for requiring domestic sourcing of materials and supplies used in projects. This requirement means that firms would need to have better knowledge of domestic sources of materials and supplies. By coordinating some of its sourcing decisions between its regional offices, firms could be more aware of the availability and quality of local supplies.

The emergence of third world capabilities, specifically small firms in a country's formal and informal construction sectors, is forcing the large international contractors to seek linkages with these firms. As the ability of these firms to undertake construction projects increases, they will start to take work away from the large foreign firms, especially if home governments favor their own firms when awarding certain contracts. The big firms must decentralize, possibly by acquiring smaller firms, to remain competitive.

With the internationalization of the financial markets, project financing can now be obtained in many different countries. Large contractors with access to financial markets with excess lending capability, through their subsidiaries located in particular countries, will become more competitive by being able to arrange the project financing as well as doing the construction. The result is a more decentralized construction firm with better coordination amongst its foreign subsidiaries.

The rapid advance in communication technology (computers, data processing, telecommunications), which makes it easy to communicate and transmit information between different locations across the globe, may alter the traditional organizational structure of construction firms. Common usage has replaced the term communication technology with information technology, so I will use the latter term in this thesis. The technology is already affecting organizations in other industries by increasing the feasibility for new linkages between firms, creating a flatter organizational structure, and altering the decision making process. Such changes may have direct consequences for construction firms. This means that some of its functions may be physically detached from the main office, without any loss of efficiency or productivity. For instance, the design of a project may be done in one country where the firm has a particular competitive advantage in design. The completed design can be transmitted back to the home office or to the actual project site.

Purpose

The primary purpose of this thesis is to explore the information technology issue in more depth, by considering the impact it could have on the relationship between the head office and project office. I will specifically try to determine the effect on the locus of decision making and deployment of project management staff.

Methodology

My methods will involve a literature search to understand the

underlying reasons for why construction firms are organized as they are in an attempt to gauge the impact of information technology. I will also look into the literature to see the effects information technology has had and is having on other organizations. Based on my findings, I will try to predict the impact information technology will have on construction firms.

Objectives

The construction industry involves large, multibillion dollar firms with a substantial amount of work at remote international locations. These firms face problems of how to manage and control remote projects and are especially handicapped at the head office by a lack of information from the project site.

My contention is that the basic head office-project office relationship in large construction firms has not been changed dramatically by information technology. Projects operate autonomously from the head office with the project manager having ultimate control over operating decisions. With advances in information technology in terms of rapidly processing information and quickly transmitting it anywhere in the world, there are real possibilities for changing this relationship in construction, either by causing greater centralization of decision making and staff or by enabling the head office to more closely monitor the decentralized activities at project offices. By studying the effects information technology has had on other organizations, I hope to draw parallels for how it might impact the construction industry.

Preview of Chapters

In Chapter two, I use organizational theory to explain why construction firms are organized the way they are. In Chapter three, I explain the impact which information technology has had on organizations. In Chapter four, I explore the viability of centralizing project level management personnel and decision making to the head office via the use of information technology by drawing on its impact on other organizations.

CHAPTER 2

ORGANIZATIONAL THEORY VIEW OF CONSTRUCTION FIRMS

INTRODUCTION

This chapter takes an organizational theory view of why construction firms are organized the way they are. I explore several areas including age of the industry, technical system, and environment to explain the organizational characteristics of construction firms. It is my belief that certain special characteristics will affect the eventual impact of information technology on construction.

AGE OF INDUSTRY

This section considers the effect of age of the construction industry on organizational structure. In a theory developed by Arthur Stinchcombe¹, he asserts that there is a correlation between the age of an industry and the present organizational structure of firms in that particular industry.

The theory is based on two postulates. The first is that economic and technical conditions determine the appropriate organizational form for a given organizational purpose. Essentially, the organizational structure that is created enables the firm to operate as efficiently as possible in the current environment. The second postulate is that certain kinds of organizations and the

1. Stinchcombe, Arthur L., "Social Structure and Organizations", in J.G. March (ed.), Handbook of Organizations, Rand McNally, 1965, Chapter 4.

associated technical systems could not be invented before the social structure was appropriate for them. As will be shown later, the bureaucratic structure became necessary in the industrial era when the growth and complexity of intrafirm communication required an organizational form which could handle these information flows efficiently.

Stinchcombe also noticed that certain structural characteristics of a type of organization are remarkably stable over time. He attributes this to the fact that firms continue to function effectively with the original organizational form to the extent that the technical and economic conditions remain the same. Also, these structures become institutionalized over time, making change more difficult.

In order to substantiate his theory, Stinchcombe studied several industries grouped into four categories based on their approximate age. Statistics were compiled on the composition of the labor force in each industry. The results are shown in Table 2.1.

The first two columns are proportions of the labor force involved in the kinship sector of the labor market, of self-employed and unpaid family workers. The third column is the proportion of clerical workers in the "middle-class administrative personnel" group made up of clerical workers, professionals, proprietors, managers, and officials. The fourth column reports the proportion of all "top status people", i.e. professionals, proprietors, managers, and officials who are professionals, thus providing an index of the development of staff structures. The variations in these figures between industry groups is indicative of changing social conditions which have led to

TABLE 2.1
 Characteristics of the Labor Force of Industries Classified by Age

Industry	% Unpaid Family Workers	% Self- Employed & Family Workers	Clerical as % Admin. Workers	Profes- sionals as % Authority
<u>Prefactory</u>				
Agriculture	13.3	76.3	0.4	0.7
Forestry, Fisheries	0.5	33.2	14	79*
Retail Trade	1.4	23.7	26	7
Construction	0.2	19.2	20	31
Hotels, Lodging	1.0	17.8	37	9
Logging	0.5	15.4	18	21
Wholesale Trade	0.2	13.3	47*	11
Printing, Publishing	0.2	5.9	51*	54*
Ship, Boat Building	0.1*	2.9*	55*	64*
Water Transportation	0.0*	1.7*	36	12
<u>Early nineteenth century</u>				
Woodworking Industries	0.1	6.0	45	14
Stone, Clay, Glass	0.1	5.4	48	45*
Leather, except footwear	0.1	3.0	52	22
Apparel	0.0	3.4	53	18
Textile Industries	0.0	1.2*	62	36
Banking, Finance	0.0	4.2	69	15
<u>Railroad age</u>				
Post Office	- -	- -	not relevant	3
Railroads, Railway Express	0.0	0.1	70	17
Street Railroads, Buses	0.1	2.0	68	28
Coal Mining	0.1	2.7	45	31
Metal Extract. & Fabric.	0.0	1.6	54	54*
Railroad and Miscell. Transportation Equip.	0.1	0.9	58	66*
<u>Modern</u>				
Automobile Repair	0.5*	23.7*	23*	4*
Telecommunications	0.1	0.4	not relevant	51
Crude Petrol, Natural Gas	0.0	5.7*	35*	55
Rubber Products	0.0	0.6	59	60
Motor Vehicles and Equip.	0.0	0.5	63	63
Electrical and Gas Utilities	0.0	0.3	62	65
Chemical and Allied	0.1	2.5	49	69
Air Transport	0.1	2.5	49	69
Petroleum, Coal Production	0.0	0.9	48	71
Electrical Machinery and Equipment	0.0	1.0	53	73
Aircraft and Parts	0.0	0.4	46	89

* Cells deviant from hypotheses.
 SOURCE: Stinchcombe

different organizational structures.

The first column shows that the prefactory industries still involve unpaid family workers to a greater extent than any of the other industries developed after that time. Stinchcombe guesses that this represents the first stage of "bureaucratization of industry", principally the differentiation of the work role from family life as noted by having essentially no family members involved in industries after the early nineteenth century.

In the second column, there is an indication of a change in the employment of unpaid family members in the work of managing the enterprise. Participation by self-employed family members drops steadily when moving down the industry groupings, from prefactory to modern. In the third column, there is a decisive break between prefactory industries and all later ones.

The so called factory organizations gave rise to more complicated coordination between different parts of the organization. To contain the interdependencies between each stage of production, a hierarchy of authority was used, which gave rise to more formal written communications and filed records. The third column shows a significant rise in the proportion of clerical workers who handle files and regularize communications between members of the organization. This indicates the origin of the bureaucratic structure as being roughly located in the early nineteenth century. The superior efficiency of bureaucratic communications allowed the size of the enterprise to expand somewhat, resulting in fewer top administrators as reflected in fewer "self-employed" (column 2) than in the prefactory period.

In the railroad age, top managerial positions were differentiated from kinship roles and made into occupations of employed career officials, as shown in the decline of self-employed family workers when compared to prior periods. The fourth column represents the development of staff departments, which seemed to proliferate in the early twentieth century as control of operations shifted from production personnel to a professionally-trained technical support staff.

By looking more closely at the construction industry, it is possible to notice that the basic organizational structure has changed very little. In his study, Stinchcombe examined the urban building construction industry. He noted that this industry structure was created when social conditions just prior to the industrial revolution made the structure appropriate. Principally, there was a large migration of people from rural agricultural areas to cities, creating a need for housing in a densely populated urban environment. The movement of people to the cities created a detachment from traditional dependence on the family as the principal means of occupation, as was the case in farming. This change facilitated the formation of guild-like organizations of craftsmen. Also, at this same time contracts became enforceable in the law. The concentration of a large pool of labor in the cities fostered the development of free wage labor which can move to some extent from job to job and employer to employer.

This environment led to the creation of an organizational structure which is characterized by workers, subcontractors, and trade unions that are craft-specific. The relationship between the

construction firm and the owner is defined in terms of a contract. This craft form of organization in the construction industry has persisted because it is particularly suited to the highly variable nature of the market. The subcontracting option enables construction firms to run a lean operation and negotiate with the different craft subcontractors as needed by the market, based on requirements for particular projects.

While Stinchcombe studied primarily small building contractors, some of his results may be applied, in general, to any construction firm. This is particularly true of the proportions of clerical staff and professionally-trained technical staff, relative to other industries. Construction uses fewer clerical staff workers because construction is considerably less bureaucratic than other more modern industries. Communications can be handled face-to-face by mutual adjustment between craft workers without the need for an extensive bureaucracy of clerical staff to control the information flow. Construction typically uses fewer technical staff members because of its basic craft orientation where most of the knowledge required to do the job is held by the craft worker, eliminating the need for a large technical staff to control the work as is the case for manufacturing firms.

In summary, it is apparent that the age of the construction industry affects the organizational structure of construction firms. The basic structure of craft-oriented workers and subcontractors and the use of relatively few clerical and technical support staff has changed very little over the years. This implies that the structure of construction firms continues to be well suited to the its environment.

TECHNICAL SYSTEM

Mintzberg² proposes two hypotheses to explain the influence of technical system on organizational structure. By technical system he means the collective instruments used by operators to do their work.

The first hypothesis is that the more regulating the technical system, the more formalized the operating work and the more bureaucratic the structure of the operating core of the firm. By regulation he means the influence of the technical system on the work of the operators, essentially the extent to which the operators' work is controlled, or regulated, by their instruments. The second hypothesis is that the more sophisticated the technical system, the more elaborate the administrative structure, specifically the larger and more professional the support staff, the greater the selective decentralization of decision making, and the greater the use of liaison devices to coordinate the work of that staff. By sophistication he means the complexity or intricateness of the technical system, namely how difficult it is to understand.

These two hypotheses are primarily based on an extensive study done by Joan Woodward³ in the late 1950's in England. She investigated 100 manufacturing firms that used different production (technical) systems to see what influence it had on organizational structure. She classified the firms' production systems into three

2. Mintzberg, Henry, The Structuring of Organizations: A Synthesis of the Research, Prentice-Hall, Englewood Cliffs, New Jersey, 1979.

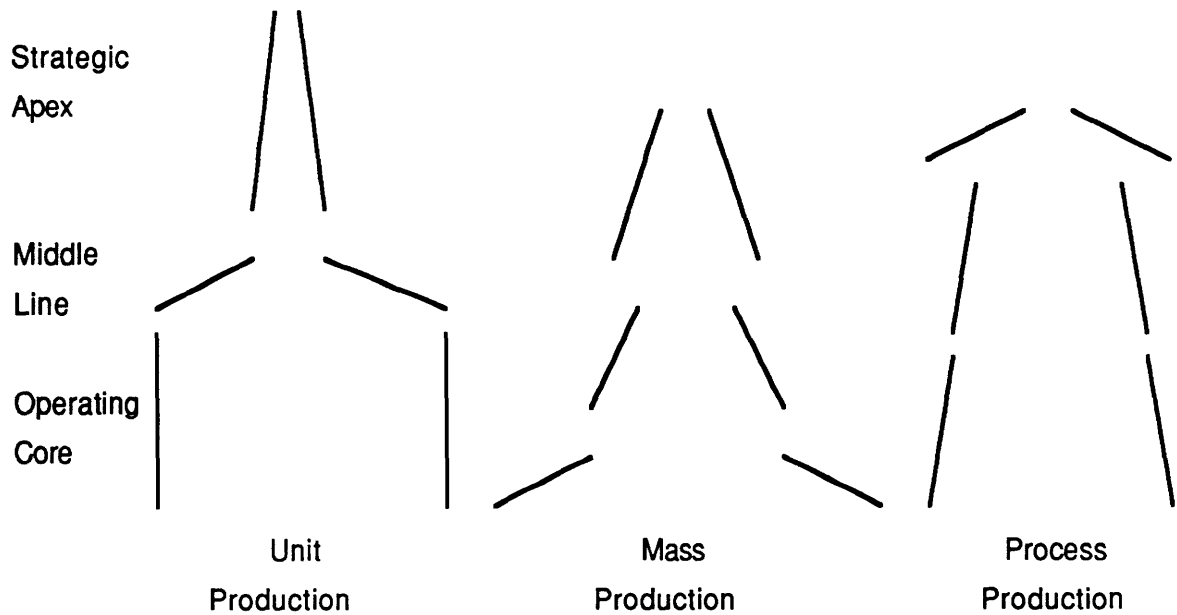
3. Woodward, Joan, Industrial Organization: Theory and Practice, Oxford University Press, 1965.

broad groupings: unit production, mass production, and process production. The categories indicated increasing technical system sophistication as well as increasing regulation. She noted by looking at firms within each group that the technical system is unrelated to the size of the firm.

She noticed a number of linear relationships in moving from unit to mass to process production. The span of control of the chief executive increased. The span of control of middle managers decreased. The ratio of managers to non-managers increased. The ratio of clerical and administrative personnel to production personnel increased. The number of levels of management in the production department increased.

There were also several curvilinear relationships. Woodward noted that the span of control of first-line supervisors was the largest in mass production firms. Mass production firms had the smallest proportion of skilled workers. Mass production firms were also bureaucratic in structure while the process and unit production firms tended to be organically structured. The results may be summarized in Figure 2.1.

Construction may be classified as unit production since generally a single item is built at a time. Also, the technical system is low in both the regulation and sophistication dimensions, which corresponds to that normally found in unit production. Though construction does not fit exactly into Woodward's definition of unit production, it does have many similarities useful for discussing the structure of construction firms.



Note: Shapes denote narrow, intermediate, and wide spans of control as Woodward described them.

Figure 2.1. Spans of Control at Three Levels in Three Technical Systems (based on findings of Woodward, 1965)

The outputs of unit production firms are nonstandard in that each output must conform to different specifications as required by the customer. The unit producers' operating work can thus not be standardized or formalized as in mass production. The resulting structure is very organic since there are no departmental lines and there must be open communication both vertically and horizontally in order to coordinate the work. At the activity level in construction, the organization is very similar to unit production. Workers must resolve among themselves any problems arising in completing a particular activity. The structure is somewhat organic at this level but as is the case in larger projects, a more formal bureaucratic hierarchy is required to coordinate all the various aspects of the

project.

Woodward characterizes unit production as being craft in nature, with the structure built around the skills of the workers in the operating core. This is particularly true of construction where each worker is generally specialized in a single craft area as are the subcontractors. The craft structure in construction explains why there are few technical support staff, the equivalent of industrial engineers in mass production. Most of the knowledge for doing the job is embedded in the worker and not in an elaborate technical system as in mass production. So instead of an extensive support staff, construction uses the first-line managers to work closely with the operators, typically in small groups. This working relationship narrows the span of control of first-line managers and is reflected in the lowest level in the unit production diagram in Figure 2.1. With most of the coordination handled by direct supervision through first-line managers, the span of control of middle-level managers can be very broad as shown in Figure 2.1.

In summary, I have identified characteristics which distinguish construction firms from firms in other industries. Construction is essentially a unit production activity, and thus the work cannot be easily standardized. This means that the work is done in small groups with close collaboration of first-line supervisors and that coordination is handled by mutual adjustment which eliminates the need for extensive clerical staff.

ENVIRONMENT

This section looks into the effect of the environment on the

organizational structure of a construction firm. The main distinguishing feature of the construction industry is the concept of a dispersed market. In such an environment, a firm must have the fluidity to move its organization to the project site. It is my contention that construction firms must station its relevant management personnel on-site because of the dispersed nature of the construction environment, thereby creating a decentralized structure.

The projects engaged in by construction firms are usually large facilities tied to a particular geographic location. As such, the various parts of the product, i.e. the facility, cannot be built in several factories and shipped to another factory for final assembly, as is done in an international manufacturing firm which builds automobiles. Auto firms may purchase various subassemblies from anywhere in the world where the cost advantages are the most favorable. It can also choose the location for assembling the entire car based on similar criteria. The construction industry, on the other hand, is unable to do this. A construction firm is able to buy some of its basic materials and equipment from wherever it chooses for the lowest cost, but a major resource, i.e. labor, must be obtained at the project location. Another thing, a construction firm cannot choose where to manufacture its product. It must build the product where the owner wants it to be located. Consequently, the construction "factory", principally the project and construction management personnel, must physically move to the project site.

The project form of grouping is the most efficient way to reduce coordination and communication costs when building large projects. It facilitates resolution of problems at the source where

communications are easier. Thompson⁴ has noted three basic kinds of interdependencies involved in the work flow. The first are pooled interdependencies involving only the sharing of resources. For instance, at the corporate level in divisionally-structured firms, funds are allocated to each division, but there is basically no other interaction between them. This is very similar to a construction firm engaged in several projects. The daily activities on each project are independent. The only interaction is prior to project commencement when project managers are allocated money, people, and equipment to complete the job. The second kind are sequential interdependencies where the work is fed from one task to the next as in an assembly line. The third kind are reciprocal interdependencies where the work is passed back and forth between tasks.

Based on his research describing how organizations account for these various kinds of interdependencies, Thompson concluded that the basic group units are formed to handle reciprocal interdependencies since these are the most complex and most costly. In the next succeeding level, groups are shaped according to sequential interdependencies. And finally in the upper most levels, groups are formed to facilitate the handling of pooled interdependencies, the least complex and costly.

The project form of grouping employed by construction organizations approximates this method very closely. Within work groups doing a particular activity, such as laying a concrete floor slab, coordination is handled by mutual adjustment between work

4. Thompson, James D., Organizations in Action, McGraw-Hill, 1967.

group members. This resembles reciprocal interdependencies. Interactions between work groups doing different activities are handled by the next higher level. For instance, if the concrete floor slab group delays in finishing its work, frictions could occur with succeeding groups that need to be in that area to begin their work by a certain date. The problem would have to be resolved by the construction manager in charge of that area of the project. This resembles sequential interdependencies. Successive levels in the project organization would seek to resolve further sequential interdependencies between different areas on the project site with the goal of resolving the problems on the project level without having to defer them to the head office. So, essentially, the project organization tries to handle reciprocal and sequential interdependencies while the head office handles pooled interdependencies between different projects.

Another reason why the project grouping is most appropriate for construction firms is that it is the only way to construct something on a large scale. As shown in Figure 2.2, various resources must be brought onto the project site in order for the construction to take place. At each of the intersections, someone must be physically on the job site to monitor developments and resolve problems. For instance, a materials management person must be on-site to count the number of each material item received and to ensure that it is not damaged, as well as issuing materials to each job activity. This follows for interactions with labor and with subcontractors. Some problems do not lend themselves to be easily comprehended by someone remote from the project site, i.e. at the head office. Having

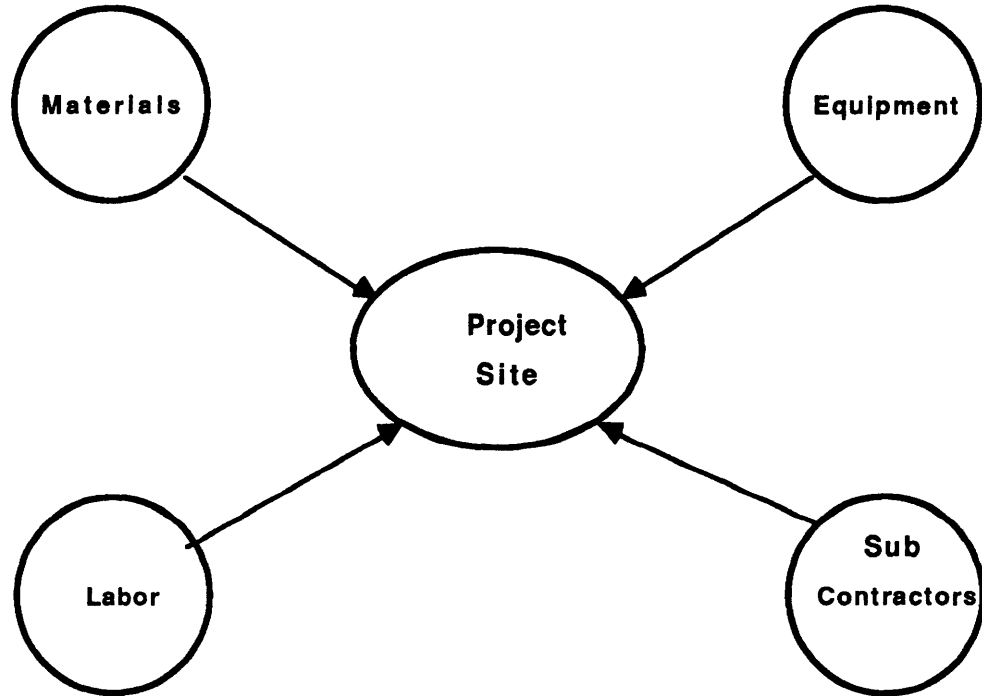


Figure 2.2. Schematic Representation of a Construction Project

someone stationed on site is the best way to resolve such problems.

The project grouping concept lends itself to decentralized decision making since it allows the organization to respond quickly to local conditions. In research by Lawrence and Lorsch⁵, they found that power for the decision process tends to rest at that level in the organization where the necessary information can best be accumulated. This explains why operating decisions are decentralized to project sites. Paterson⁶ developed a framework for understanding control over the decision process. He depicts the process as a number

5. Lawrence, Paul R. and Lorsch, Jay W., Organization and Environment, Irwin, 1967.

6. Paterson, T.T., Management Theory, Business Publications Ltd., 1969.

of steps, as shown in Figure 2.3. The steps are: 1) collecting information to pass on to the decision maker about what can be done; 2) processing that information to present advice to the decision maker about what should be done; 3) making the choice, that is determining what is intended to be done; 4) authorizing what is intended to be done; and 5) executing what is done. In a construction firm, each of these steps is best accomplished on site because field personnel are in a position to understand the choices involved in a decision and any extenuating circumstances.

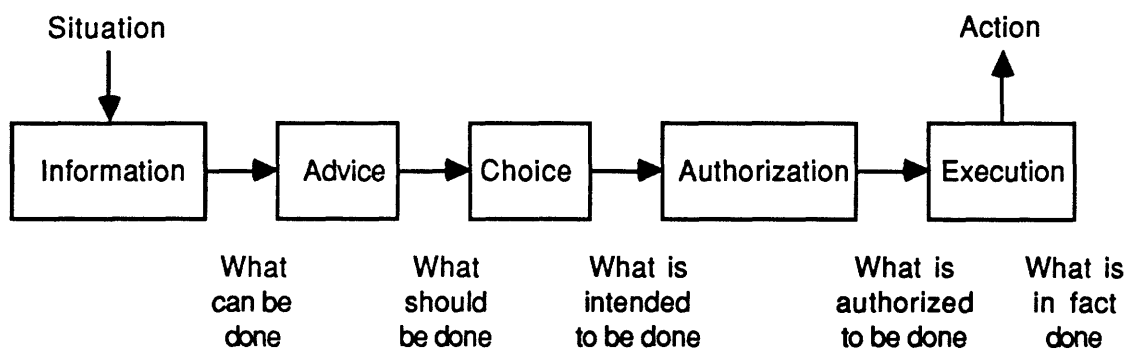


Figure 2.3. A Continuum of Control over the Decision Process

SOURCE: Paterson (p. 150)

In this section I have explained the reasons why construction firms employ a project form of organization and are therefore using decentralized decision making. The dispersed nature of construction means that firms must go to the project, instead of the project coming to the firm. Also, construction requires that numerous resources be assembled on the project site for the work to be completed. The physical presence of management personnel is needed

to handle the interactions between these resources and the rest of the project. These people have first hand knowledge of project problems, thus a decentralized form of decision making is best suited to this situation.

CONCLUSION

In this chapter, I have considered the construction organization in terms of organizational theory. It is apparent that the age of the industry, technical system, and environment play roles in determining the most appropriate structure for a construction firm. One which is characterized by a craft orientation, relatively few clerical and technical support staff, and a dispersed market where the firm must physically go to the project site. These factors will help determine the impact of information technology on construction.

CHAPTER 3

THE IMPACT OF INFORMATION TECHNOLOGY ON ORGANIZATIONS

INTRODUCTION

Information technology is revolutionizing the way things are done in organizations. The most profound changes are new linkages, both within and between organizations, flattening the organizational structure, and the different way decisions are made. The improved communication capability of information technology is making new organizational forms quite feasible.

In the past, it was difficult to achieve centralized control and coordination in a geographically dispersed organization which was at the same time responsive to changing customer preferences. The typical response was to control the dispersed units with standard rules and procedures. Decisions were referred up the hierarchy with very little decision making authority residing at the local level. Local managers had to endure lengthy delays in trying to effect even small changes in the company's product as an example from Xerox¹ indicates. A Xerox manager had been trying for nine months to obtain approvals to add slightly more intense light bulbs to copiers so he could compete in Egypt, where penciled material typically is copied. The system of checks and balances inherent in an elaborate hierarchy can prevent colossal mistakes, but it also precludes ingenuity and innovation.

1. Special Report, "The Shrinking of Middle Management", Business Week, April 25, 1983, p. 55.

Such a structure is adequate in a stable environment with little serious competition where change occurs very slowly but it does not work well otherwise. Now, with a more complex and turbulent competitive environment, there is even more of a need to have a flexible, adaptive organization which can respond rapidly. Such an organizational structure that has characteristics of both centralized and decentralized organizations is becoming feasible via information technology.

LINKAGES

In terms of linkages, information technology is opening new means of communication within firms as well as between firms. The impact of information technology in a firm is apparent with the shift towards work-group computing² in which a variety of employees in different departments share computer resources across a network. The technology serves to communicate the work of a group member to all other group members. The group can coordinate the work amongst themselves, thereby eliminating the need for and the subsequent delays in having a human manage the process, thereby improving the productivity of the office.

The concept of work-group computing has been brought about through advances in computer technology, which has affected the way computers are used in firms. When first introduced, computing facilities were concentrated in a single department, usually the information systems (IS) department. Other departments had to

2. Goldstein, Mark L., "The Networked Organization", Industry Week, April 18, 1988, p. 46.

arrange to have computer processing tasks done through the IS department. As the demand for computer services increased, enormous backlogs developed in IS departments, which affected productivity throughout the company.

With the development of personal computers, reliance on centralized IS departments began to lessen. Companies started buying personal computers to reduce the demand on large mainframe computers or, in some cases, to eliminate them altogether. An example of the latter is Fish Engineering and Construction³, a Houston-based firm which designs and builds natural gas, petroleum, chemical, and refining plants around the world. In 1988, the company shifted from a mainframe to a system of personal computers to improve productivity. It needed a networked system that the 200 home-office employees could use and which could also link them with 1500 field employees at remote locations. The push towards improved productivity is driving firms into taking increasing advantage of the linking capability embedded in the personal computer technology. Goldstein⁴ sees this shift towards work-group computing as slowly but surely replacing many of the tasks once performed by the centralized IS department.

Information technology is also contributing to the formation of interfirm linkages, primarily because it reduces the transaction costs of controlling and coordinating the activities between different

3. Handley, Cathy, "Pulling the Mainframe Plug", Purchasing, May 26, 1988, p. 56-57.

4. Goldstein, Mark L., "The Networked Organization", Industry Week, April 18, 1988, p. 46.

firms. An example of this relationship is in the domestic apparel industry⁵. Information technology is used to link retailers, apparel manufacturers, and fabric producers into a single network in the face of intensifying foreign competition. The objective is to shorten the time between order and delivery, reduce inventory levels, and slash waste by more closely matching consumer demands and production. A very similar arrangement is apparent in the automobile industry. The major auto companies link up with their suppliers by giving them lists of parts required for the next period's production and specifying the precise time when the specified quantities should be delivered to the plant. This relationship was created to improve competitiveness in response to increasing foreign competition. These examples of vertical linkages demonstrate the ability to reduce inventories and to better respond to customer demand if the right information can be quickly and accurately transmitted at low cost.

There is beginning to be some evidence of horizontal linkage between different firms with the aid of information technology. With faster electronic communications and more extensive electronic data, Dyson⁶ believes it is now possible for a group of different firms working together in different roles to link together and form what amounts to a single "virtual" company. She believes that if you can specify exactly what you are ordering and can keep in touch on quality, timely delivery, and keep good records, then you can safely

5. Berger, Paul, "Real Strategic Successes", Computer Decisions, April 1988, p. 15.

6. Dyson, Esther, "Coordination Technology", Forbes, August 8, 1988, p. 96.

buy from the outside. As an example, she cites a company called Magicorp, based in Wilmington, Ohio. It runs a slide-making shop, and relies on other companies for the rest of its operations. People who use graphics software on their personal computers and who need overhead slides made send the data by phone to Magicorp's office in Wilmington. Once the slides are ready, they can be delivered quickly anywhere in the United States because Airborne Express' hub is also located in Wilmington. As for marketing, Magicorp relies on graphics software vendors to promote its services, for which it pays them a royalty.

There are also possibilities for horizontally linking larger firms. Miles and Snow⁷ have developed arguments applicable to larger firms with their concept of a dynamic network. Their work is based on the premise that in the present and apparently future climates of rapid technological change and shifting patterns of international trade and competition, a new organizational form is required. As evidence for the formation of such a structure, they cite trends already evident in several industries showing the increased use of joint ventures, subcontracting and licensing activities occurring across international borders, and new business ventures spinning off of established companies. The dynamic network refers to a new structure between firms in the same industry. Organizations in an industry can generally be classified as following one of three generic strategies: 1) Prospectors are "first-to-the-market" with a new

7. Miles, Raymond E. and Snow, Charles C., "Organizations: New Concepts for New Forms", California Management Review, Spring 1986, p. 62-66.

product or service and differentiate themselves from their competitors by using their ability to develop innovative technologies and products; 2) Defenders offer a limited, stable product line and compete on the basis of value and/or cost; 3) Analyzers pursue a "second-in" strategy whereby they imitate and improve upon the product offerings of their competitors.

A dynamic network, shown in Figure 3.1, suggests that its major components can be assembled and reassembled in order to meet complex and changing competitive conditions. This is what Miles and Snow have in mind with a few additional characteristics:

- 1) Vertical Disaggregation - Business functions such as product design and development, manufacturing, marketing, and distribution, typically conducted in a single organization, are

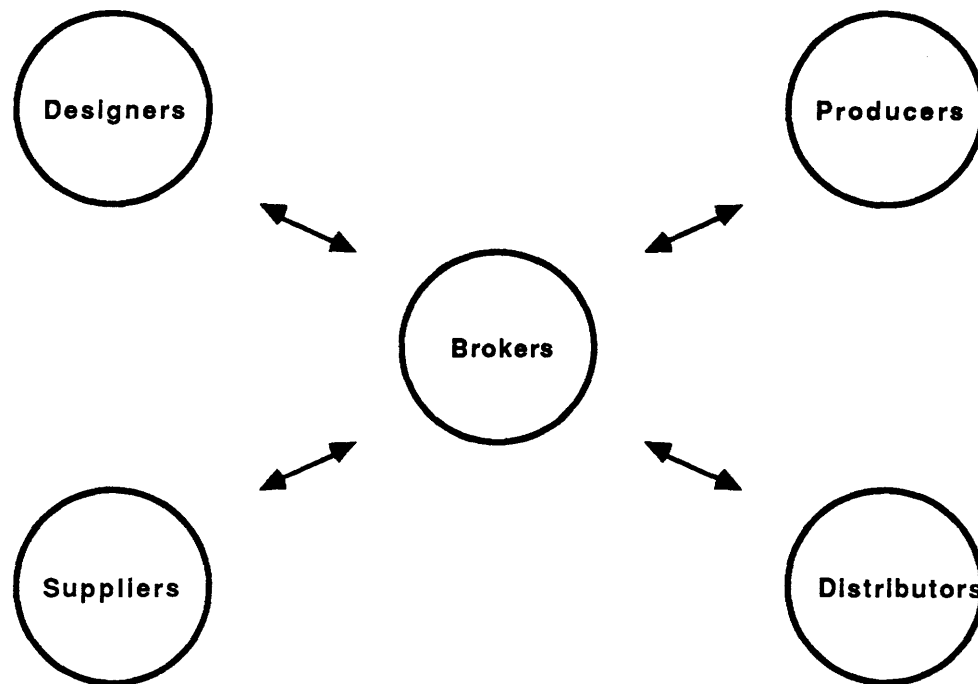


Figure 3.1. A Dynamic Network
SOURCE: Miles and Snow

performed by independent organizations within a network. In terms of the generic strategies mentioned earlier, Prospectors essentially play the designer role within an industry, Analyzers play the marketing/distribution role (and also contribute as information brokers), and Defenders perform the producer role. Networks may be more or less complex and dynamic depending on the competitive circumstances.

- 2) Brokers - Because each function is not necessarily part of a single organization, business groups are assembled by or located through brokers. In some cases, a single broker plays a lead role and subcontracts for needed services. In other cases, linkages among equal partners are created by various brokers specializing in a particular service. In still others, one network component uses a broker to locate one or more other functions.
- 3) Market Mechanisms - The major functions are held together in the main by market mechanisms rather than plans and controls. Contracts and payment for results are used more frequently than progress reports and personal supervision.
- 4) Full-Disclosure Information Systems - Broad-access computerized information systems are used as substitutes for lengthy trust-building processes based on experience. Participants in the network agree on a general structure of payment for value added and then hook themselves together in a continuously updated information system so that contributions can be mutually and instantaneously verified.

Such an organizational structure enables a firm to pursue its own

particular distinctive competence. Information technology plays a central role in this new structure by facilitating information exchange and coordination. It removes the need for a firm to internalize all the different functions as well as to support a bureaucratic hierarchy to manage the information flows between the functions. This implies that individual firms will be much flatter since the interdependences which exist between functions will be handled outside of the firm through the previously arranged value added payment structure. McClenahan⁸ supports this view by predicting that successful companies of the 1990's will be flattened organizations because of the greater need to put both managers and employees closer to customers.

FLATTENING THE STRUCTURE

The impact of information technology in flattening the organizational structure is more indirect than the case for linkages. In response to the severe economic conditions in the early 1980's as well as a general lack of competitiveness against foreign firms, many U.S. firms began restructuring their organizations, which included downsizing, to cut costs. A big portion of the cuts came by eliminating several middle management levels. This seems to indicate that large bureaucratic hierarchies, with the inherent inability to react quickly, may have outlived their usefulness as a means of coordinating and controlling a complex, far-flung enterprise. The information revolution may in fact be contributing to the more

8. McClenahan, John S., "Flexible Structures to Absorb the Shocks", Industry Week, April 18, 1988, p. 41-42.

dynamic present environment since information can be collected, processed, and distributed more rapidly enabling firms to act and react more quickly to customer demands and the moves of competitors. In this situation, "too many layers of management simply impede effective management by acting as an information filter and stalling decisions"⁹.

The bureaucratic structure is better suited to a more stable environment where operations can be handled by standard rules and procedures, but it tends to become bloated with additional management layers over time. These new managers become another link in the reporting chain - a gatekeeper to ensure that things stay within bounds, an interpreter of even bigger bosses, and a message carrier to higher levels - without adding any particular value and only compounding the difficulties of coordination when the organization is subjected to a dynamic environment where it must respond quickly.

An example cited by Magee¹⁰ demonstrates some of these problems. He describes the efforts of a major insurance company to reduce its hierarchy. The company had originally built up its structure to support a system of management control and specialization during decades of business stability. The firm has come to realize, however, that, in some cases, new layers of management had occasionally been added simply to provide opportunities for recognition. For example, an outstanding professional, like a senior actuary, might be given the title of

9. Magee, John F., "What Information Technology Has in Store for Managers", Sloan Management Review, Winter 1985, p. 48-49.

10. Magee, p. 49.

assistant manager. Unfortunately, once the person got the title, he or she tended to try to manage, usually with unhappy consequences for all concerned. The layers hindered the company's competitiveness in what has become a very dynamic, competitive business climate.

With fewer middle managers, conditions were ripe for the broader application of information technology which would allow the remaining managers to operate with broader spans of control. This necessity is almost inevitable since in flattened hierarchies operating with fewer managers, "the flow of information between managers and workers and the amount of information shared by them will have to evolve"¹¹, which has implications for the location of decision making authority within the organization. As noted by Drucker¹², restructuring the organization around information will invariably result in a drastic cut in the number of management levels and with the number of "general" management jobs, ostensibly because of the capability of information technology to automate and eliminate many of the tasks previously done by these management levels. Information technology allows companies to reduce middle management ranks because technology, not people, can collect, process, and pass information around the firm, facilitating broader spans of control. Wendt¹³ notes that typical manager-subordinate relationships used to be conducted face to face, thereby limiting a

11. Altany, David R., "Decision-Making Trickles Down to the Troops", Industry Week, April 18, 1988, p. 34.

12. Drucker, Peter F., "Tomorrow's Restless Managers", Industry Week, April 18, 1988, p. 25.

13. Wendt, Henry, "The Multinational of Tomorrow", Across the Board, September 1985, p. 54.

manager's span of control, but as a result of information technology, they can now be handled with much less expenditure of personal time. The effect is to increase the span of reporting relationships as well as to improve communication and motivation.

There is some indication that the trend towards a reduced number of middle managers is not a broad ranging phenomenon. Goldstein¹⁴ notes that only the largest U.S. corporations - indeed, a minority of companies - are enduring such painful transformations. In small and mid-sized firms across the country the ranks of middle managers are actually growing.

In support of this, Kanter¹⁵ says that the number of attractive jobs equivalent to those of traditional managers is probably increasing rather than declining. As an example, she cites a five-year study of a household products company which had changed to self-managed work groups. The results indicated that there were still as many "managers" as before, but they were doing dramatically different things. There were fewer line supervisors, but more planners, strategists, and project leaders. This seems to imply that the environment and information technology are changing the roles of middle managers, away from pure supervisory functions and towards a role of "initiators of innovation", as referred to by Kanter.

14. Goldstein, Mark L., "What Future for Middle Managers?", Industry Week, December 18, 1986, p. 47.

15. Kanter, Rosabeth Moss, "The Reshaping of Middle Management", Management Review, January 1986, p. 19.

DECISION MAKING

The biggest impact of information technology on decision making in the future will be the ability to make faster decisions based on more accurate, and unfiltered data, especially as a force for centralizing the process. While complete centralization is a very real possibility, certain environmental and human factors will mitigate against it in favor of a mixed structure. A structure with technology-driven control systems that supports the flexibility and responsiveness of a decentralized organization as well as the integration and control of a centralized organization.

Centralized Decision Making

A logical extension of the fewer levels of middle management is that executives and senior managers will be closer to the operating level in their companies. With the capabilities of executive support/expert systems, which allow executives to bypass the remaining levels of middle management and have immediate access to operating information, there is a real possibility for increased centralization of decision making. The information received is then free of the distortion and bias from previously having gone through a relay system of analysts and middle managers, thus allowing executives to be aware of and solve arising problems much faster.

The information system of any organization contains information related to three basic types of operations¹⁶: transaction processing (Operational Support System), control (Management

16. Ismail, Ahmed, Untitled Master's Thesis, M.I.T., 1989.

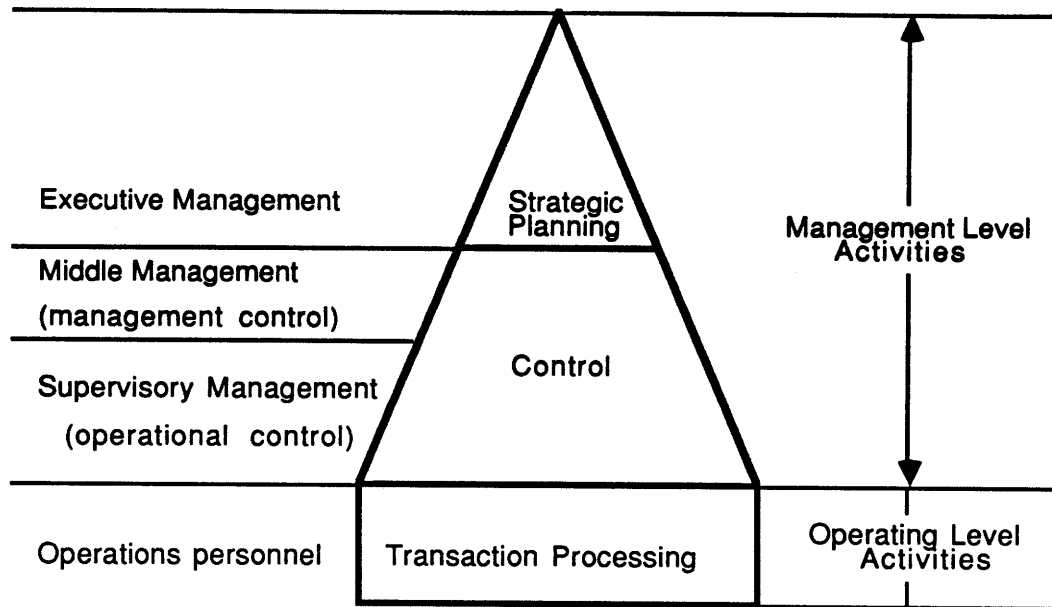


Figure 3.2. Information-related Activities of Organizations.
SOURCE: Ismail

Information System), and long-term or strategic planning (Decision, Strategic, or Executive Support Systems), as shown in Figure 3.2. The initial effect of information technology on decision making was in the lowest level of the organization by automating the well structured, repetitive decisions such as payroll and accounting, the so called transaction processing functions. As the technology improved, it began to gradually move up the organizational structure, enabling middle management to have wider spans of control.

Companies have been reluctant to adopt executive support systems in the upper levels of the organization, but there are several reasons why such systems are likely to come into wider use¹⁷. First, despite what some critics say, the use of information technology to

17. Rockart, John F. and D. DeLong, Executive Support Systems: The Emergence of Top Management Computer Use, McGraw-Hill, 1988.

support executives' decisions makes good managerial sense because it gives them immediate access to unfiltered information about current operations. Second, the technology, both hardware and software, is rapidly improving. Faster hardware, with expanded capabilities, is now being joined with easier-to-use software to create more user friendly machines. Third, computer-based executive support will continue to spread because more and more top managers are becoming computer literate, especially as younger managers are promoted.

Rockart & DeLong¹⁸ have noted three ways in which executive support systems improve organizational planning and control:

- 1) They can improve the existing corporate or divisional reporting system. While leaving the existing management control system essentially intact, executive support systems can improve reporting by: changing the way performance data are physically collected, improving data integrity, speeding up reporting, and changing the method of report presentation.
- 2) They can be helpful in improving the design of management reporting systems. Although improvements in the speed of data access, data quality, and presentation methods are very valuable, a greater opportunity is presented by today's technology, the opportunity to rethink the information needed and thus the content and structure of existing management control systems in light of current business conditions.
- 3) They can be helpful in developing more effective planning and forecasting processes. Planning and forecasting as yet are only

18. Rockart and DeLong.

occasionally the primary focus of executive support systems, but, in many cases, improved control processes seem to lead to a new focus on the planning function. Planning systems, as used here, are systems which produce targets the organization expects to meet.

The overall effect of this is to enable the executive to make decisions that were previously made in other parts of the firm, thereby centralizing more of the decisions.

The ultimate benefit of executive support or expert systems will be to make management more effective in solving those ill-defined problems by simplifying complex environments. Executive support systems enable them to assemble internal information about how the firm is performing as well as external information about such subjects as customer actions, competitive activity, regulatory changes, and general economic conditions. They also present the material in a more manageable form through the use of color and graphics which can dramatically highlight key data, helping managers to recognize and focus on significant trends, problem areas, unexpected successes, wide variances, etc. An example of this is an expert system built by the U.S. Navy¹⁹.

The system was built for the U.S. Naval Fleet Command, located in Honolulu, Hawaii, as part of their command and control system. The command has some 400 ships and four squadrons of airplanes. Coordinating the assignment of these resources is complex. And when one of the ships or aircraft cannot fulfill its

19. "Helping People Work More Effectively", I/S Analyzer, December 1987, p. 8.

mission, the fleet command must find a replacement; that can be an even more complex problem.

This application has two parts. First, the command needs to learn that a problem exists - and the sooner the better. Second, it may need to find a replacement - quickly.

To handle the first part, the Navy has created a natural language, text understanding system that reads (and 'understands') the 1000 to 2000 messages the command receives each day. The system looks for messages that might require action by the fleet command. When it encounters such a message, it alerts the watch operator. So, this system is helping the Navy improve its efficiency in handling the large number of messages it receives each day.

To deal with the second problem - selecting a replacement resource - the Navy has developed an expert system to help them consider alternatives. Before the expert system was available, it generally took naval personnel one day to find a substitute aircraft carrier and another week to find two escort ships - after a cursory review of all the possibilities quickly eliminated most alternatives. Due to the amount of information they had to consider, naval personnel could carefully examine only five or six possible alternative replacements.

With the expert system, naval personnel can now carefully examine all possible replacements, and in much less time. On one occasion, they were able to seriously consider 40 possibilities and arrive at the best choice in seven hours. The expert system simplifies this complex environment by applying 'if....then' rules to all potential replacements - something naval personnel could not do

manually because of the volume of work involved. Once the system has narrowed down the choices to five or six, naval personnel select the best one. Since the system now allows them to consider each alternative carefully, their effectiveness has improved. So, by using these two information systems, naval personnel believe they are monitoring their complex environment better, responding faster, and making better decisions in emergencies.

Limits to Centralization

But there is some limit to the use of information technology, especially with the increasingly centralized control of decision making as implied above, since the human brain has only limited ability to process all the information which is collected with increasing speed. A comment made by Simon²⁰ in 1973 is still applicable today. He said that in our contemporary world, the scarce resource is not information; it is the processing capacity to attend to the information. No matter how much decision making can be centralized with information technology, there is still a point that is reached when it is no longer possible to monitor and control the results of the process, a situation commonly referred to as data overload²¹. Beyond that point, the process of collecting information, making decisions, monitoring feedback, and evaluating performance breaks down. Sometimes the necessary information cannot be brought

20.Simon, H.A., "Applying Information Technology to Organization Design", Public Administration Review, 1973, p. 270-271.

21.Applegate, Lynda M.; Cash, Jr, James I.; and Mills, D. Quinn, "Information Technology and Tomorrow's Manager", Harvard Business Review, November-December, 1988, p. 136.

to a centralized location because too much of it is soft and difficult to transmit. This implies that some degree of decentralization is required. There are also environmental factors which mitigate against purely centralized control, specifically the need to be close to the customer.

Need for Mixed Structure

This need to be responsive led to even more decentralized decision making. The unique feature of information technology is that it can facilitate the transformation into a structure that supports the flexibility and responsiveness of a decentralized structure as well as the integration and control of a centralized structure. This capability has been aided by the development of personal computers which enable firms to geographically disperse their computing facilities. Much of the computing previously done on a centralized basis in the corporate headquarters can be decentralized to local offices with the result of making faster decisions at the local level to meet the customers' immediate needs. It essentially removes the delay of having to process data at a central location.

An example of where information technology has been used to create this flexibility in control and decision making is at Grand Metropolitan²², a British-based conglomerate. The Grand Metropolitan Information Services (GMIS) division provides computer and telecommunication services to Grand Metropolitan. One of its functions is to provide a company-wide computerized data collection

22. I/S Analyzer, p. 1-3.

service that gathers data from Grand Metropolitan's retail stores, hotels, pubs, restaurants, and clubs. Sales data from a retail outlet is captured by the data collection system and uploaded to the district or branch computer where information technology is processed to create analyses and management summaries. An analysis can be very detailed for instance a restaurant manager can get a listing of the previous day's sales by item and time of day information technology was sold and is able to see the effect of, for example, a local promotion campaign. This system gives both corporate management and retail proprietors more up-to-date information about their operations and enables retailers to run more efficient and effective operations.

This example shows that the quality of marketing decisions has been significantly improved by the application of information technology. The local manager knows much more quickly about the effectiveness of a particular advertising campaign. Since the results are rapidly distributed throughout the organization, the corporate marketing people can collaborate with the local manager to analyze the results and plan future campaigns.

CONCLUSION

In summary, I have described the impacts of information technology on organizations in terms of new linkages, flattening the structure, and decision making.

Information technology is creating new possibilities for both intrafirm and interfirm coordination. Within the firm, the practice of work-group computing is improving office productivity. Between

firms, two different types of linkages are possible since information technology has reduced the transaction costs of controlling and coordinating interfirm activities. Vertical linkages are occurring where firms involved in different stages of the business production cycle from manufacturing to distribution to retailing are sharing information as a means for responding more quickly to customer demand. Based on the fact that the environment in business is becoming more complex and competitive, some experts are proposing a new form of horizontal linkage called a dynamic network. Each firm in the network concentrates on a particular strength. Payments are based on a prearranged agreement on the value added by each firm in the network with a broad access computerized information system that instantaneously verifies all contributions.

The new economic and competitive forces in the present environment are rendering the bureaucratic hierarchy obsolete. The result is a flatter organizational structure with fewer middle management levels. Information technology facilitates the formation of such a structure by broadening the spans of control.

Regarding decision making, information technology creates the possibility for centralizing the process since it can rapidly collect and analyze information, especially with the aid of expert systems. Human limits in handling all the information as well as certain environmental factors mitigate against the complete centralization of decision making. Instead, a mixed structure is favored which offers attributes of a flexible, responsive decentralized organization as well as the integration and control of a centralized organization.

CHAPTER 4

THE IMPACT OF INFORMATION TECHNOLOGY ON THE HEAD OFFICE/PROJECT OFFICE RELATIONSHIP

In Chapter two, I explained the structure of construction firms based on organizational theory research. I tried to point out special characteristics of construction, especially the concept of a dispersed market, which distinguish construction as engaged in unit production from other industries engaged in either mass or process production. In Chapter three, I considered some of the major impacts which information technology has had on organizations in general. Most of the effect has been to facilitate a change in organizational structure caused by a more competitive environment.

My intention in this chapter is to combine the results of the previous chapters to predict how information technology will impact the relationship between the head office of construction firms and its remote project offices. On the surface, it appears that project level management personnel and decision making could become more centralized in the head office with the capability of information technology to rapidly process and transmit information, but my analysis indicates otherwise. Based on the nature of construction, I believe that project management staff and decision making will not be centralized to any great extent. Rather, these activities will remain decentralized to the project offices, but with one noticeable change. Information technology will facilitate better centralized monitoring of projects.

In the remainder of the chapter, I will discuss each of the

three impacts of information technology mentioned in Chapter three, i.e. linkages, flatter organizational structure, and decision making, in relation to their expected effect on construction firms.

As for new linkages which are possible via information technology, there are possibilities for better coordination and control of intrafirm activities. The rapid exchange of information between remote sites can foster a closer relationship between the head office and project office. Personnel at the project site may more easily contact and consult the head office. The result could be less of a need to station support personnel at the project office. People dealing with environmental and job safety issues could stay at the head office with project management staff consulting them as the need arises. Any design changes could be made at the head office with the new drawings transmitted electronically back to the project site, thereby eliminating the need for designers to be on site. At the same time, the head office can be continuously aware of developments on the project site through on-line information systems. This would eliminate major surprises and enable the head office to support project staff.

In the case of new linkages between firms, the concept of a dynamic network as discussed by Miles and Snow is already closely approximated by the basic process of construction. It operates as a network since construction firms are able to subcontract parts of the job in order to assemble the various resources required to undertake a particular job. Payment to each subcontractor is based on performance by satisfactorily completing the portion of the total job as described in the contract.

The impact of flatter organizational structures caused by information technology does not really apply to construction since construction firms are by nature very lean organizations. Without a readily assured continuing demand, construction firms cannot afford to expand their hierarchy. Also, since most of the project communications are handled face-to-face on the project site, there is no real need to have an elaborate administrative hierarchy to handle interactions, as in mass production firms. The craft nature of construction means that most of the knowledge to do the job is held by the worker, so a large technical support staff is not needed to control the work.

The application of information technology to the decision making process has some very real possibilities for altering the head office-project office relationship in construction firms, but some special characteristics of construction will limit the impact. In Chapter two, I reasoned that project management staff are best suited to be stationed at the project site to handle the interactions between labor and subcontractors and deliveries of materials and equipment. This was based on the realization that construction operates in a dispersed market in which the firm must physically move its management personnel to the project site in order to undertake the work. With these people on site, it makes sense to keep decision making decentralized to the project level for two reasons. One, they are in the best position to understand and resolve problems since they are physically closer to the situation. Two, decisions are best made where the relevant information can be most easily collected, especially when some of the information is soft and

difficult to transmit.

Whereas the locus of decision making in a construction context will not really change because of information technology, it does not mean that a project office will continue to function with complete autonomy. Instead, information technology can play a role by increasing the monitoring capability of remote project activities. The advances in information technology enable project information to be rapidly collected and transmitted back to the head office. As events transpire, the head office can monitor the results and costs instead of allowing the project manager complete autonomy. If major problems begin to develop on the project, the head office can know about it immediately and provide support to the project manager. The head office is able to support the project manager as needed but without centralizing decision making.

BIBLIOGRAPHY

- Altany, David R., "Decision-Making Trickles Down to the Troops", Industry Week, April 18,1988, p. 34.
- Applegate, Lynda M.; Cash, Jr, James I.; and Mills, D. Quinn, "Information Technology and Tomorrow's Manager", Harvard Business Review, November-December, 1988, p. 128-136.
- Berger, Paul, "Real Strategic Successes", Computer Decisions, April 1988, p. 15.
- Drucker, Peter F., "Tomorrow's Restless Managers", Industry Week, April 18,1988, p. 25.
- Dyson, Esther, "Coordination Technology", Forbes, August 8,1988, p. 96.
- Goldstein, Mark L., "What Future for Middle Managers?", Industry Week, December 18, 1986, p. 45-56.
- Goldstein, Mark L., "The Networked Organization", Industry Week, April 18,1988, p. 46-47.
- Handley, Cathy, "Pulling the Mainframe Plug", Purchasing, May 26, 1988, p. 56-60.
- "Helping People Work More Effectively", I/S Analyzer, December 1987, p. 1-12.
- Ismail, Ahmed, Untitled Master's Thesis, M.I.T., 1989.
- Kanter, Rosabeth Moss, "The Reshaping of Middle Management", Management Review, January 1986, p. 19-20.
- Magee, John F., "What Information Technology Has in Store for Managers", Sloan Management Review, Winter 1985, p. 45-49.

- Lawrence, Paul R. and Lorsch, Jay W., Organization and Environment, Irwin, 1967.
- McClenahan, John S., "Flexible Structures to Absorb the Shocks", Industry Week, April 18, 1988, p. 41-42.
- Miles, Raymond E. and Snow, Charles C., "Organizations: New Concepts for New Forms", California Management Review, Spring 1986, p. 62-73.
- Mintzberg, Henry, The Structuring of Organizations: A Synthesis of the Research, Prentice-Hall, Englewood Cliffs, New Jersey, 1979.
- Paterson, T.T., Management Theory, Business Publications Ltd., 1969.
- Rockart, John F. and DeLong, D., Executive Support Systems: The Emergence of Top Management Computer Use, McGraw-Hill, 1988.
- Simon, H.A., "Applying Information Technology to Organization Design", Public Administration Review, 1973, p. 268-278.
- Special Report, "The Shrinking of Middle Management", Business Week, April 25, 1983, p. 54-61.
- Stinchcombe, Arthur L., "Social Structure and Organizations", in J.G. March (ed.), Handbook of Organizations, Rand McNally, 1965, Chapter 4, p.142-193.
- Thompson, James D., Organizations in Action, McGraw-Hill, 1967.
- Wendt, Henry, "The Multinational of Tomorrow", Across the Board, September 1985, p. 49-56.
- Woodward, Joan, Industrial Organization: Theory and Practice, Oxford University Press, 1965.