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USE OF INFORMATION TECHNOLOGIES FOR INTER-UNIT COORDINATION: A CASE STUDY

Sue Conger
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ABSTRACT

Organization, MIS, and media choice theories all try to describe how information flows through a business organization. Organization theory concentrates on the use of interpersonal methods of communications. MIS theory focusses on computer-based technologies for communications. Media choice theory concentrates on factors that contribute to selection of communication medium. Each research area tends to ignore the others. The result is conflicting and often irreconcilable conclusions.

One important subset of business communication is the flow of information to coordinate the activities of various units of a company. In this study, the selection of coordination methods for one type of job is analyzed. Based on a case study of equity traders, a theory of information coordination is hypothesized for future empirical evaluation. The hypotheses synthesize and reconcile the organization, MIS, and media choice literature. The case results presented in this work exemplify the hypothesized relationships.

1. INTRODUCTION

This research studies factors that influence the choice of inter-unit coordination methods. Successful coordination synchronizes work between different, but interdependent, individuals, units or organizations (Lawrence and Lorsch 1967). Coordination and media choice have been researched by both organization theorists and MIS theorists with conflicting results. Organization research concentrates on task factors and communication content as determinants of media choice in business communications. When information technologies (ITs)¹ are considered in organization research, they are conduits for numerical, factual information (cf. Daft and Lengel 1984; Van de Ven and Ferry 1980). MIS researchers ignore the impact of task characteristics on the use of ITs. Task features, when considered, have been descriptive rather than factors that contribute to the media choice decision (cf. Sumner 1986). Media choice research has identified individual factors important to selection between two media. Task selection and choice among many alternatives have not been evaluated. To further complicate the issue, changes in information technologies are continuously improving the financial and

functional attractiveness of ITs. ITs cannot realistically be relegated to the limited usage described in organization theory; they cannot be described as universally applicable as in MIS theory; nor can IT use be based solely on personal and technical characteristics as in media choice.

This research is part of a larger study that seeks to reconcile the inconsistencies between organizational, MIS, and media choice research. In this work, factors are defined that influence media choice for one type of work -- information coordination. Information coordination is defined as the gathering and dissemination of information required for individuals to do their work. This study concentrates on inter-unit coordination; i.e., information exchanged between organizational units and/or organizations. The purpose of this study was to define those factors influencing choice of coordination media for future empirical work. Equity trading was analyzed as an example of a highly variable and complex task. Variation between traders was studied to develop specific hypotheses from a general research question. The research question was: Under what conditions do ITs predominate for complex, variable tasks. Only

highly interdependent jobs were studied because inter-unit coordination assumes inter-unit inter-dependence.

Linking disparate research domains is an important research contribution. Uni-domain research may be technically competent but it increasingly presents an unrealistically narrow view of organizations. The results of this study show a direction for research to reconcile the conflicting results of past research by incorporating multiple views in the research design.

The next section presents definitions of terms. Section 3 reviews theoretical background from organization, MIS, and media choice literature, and identifies limitations in each body of work that prompted this study. Section 4 identifies the elements of the problem evaluated. Sections 5 through 7 discuss the research question, case methodology, and results. The last section discusses the conclusions drawn from the case and the specific hypotheses generated for future research.

2. DEFINITIONS

Coordination. Katz and Kahn (1976) define coordination as "devices...for providing orderly and systematic articulation...of tasks and roles...such as priority setting, establishment and regulation of routines, timing and synchronization of functions, scheduling and sequencing of events." Inter-unit coordination of required information was the focus of this study.

Coordination is a subset of communication and is limited to goal-oriented, task specific exchanges of information required for the receiver to prioritize, time and sequence his/her tasks. Acts such as social exchanges, general business discussions, and actual completion of tasks are not coordination acts.

Information technologies (IT). ITs are tools that support computing and communications (McKenney and McFarlan 1983). The components of IT are technologies for data processing, word processing and teleprocessing. Data processing (DP) refers to "fundamental, routine processing of transactions and reports to support business operations" (Davis and Olson 1985). Word processing (WP) refers to technologies that support text manipulation (Meadow and Tedesco 1985). Teleprocessing (TP) refers to technologies that support data/text transmission

over long distances between computers and/or terminals (Dordick 1986). As the three technologies evolve, the once distinct features and functions are merging into integrated hardware/software environments. These environments have collectively become known as ITs.

Coordination methods. Traditional methods of coordination identified have been face-to-face meetings, telephone conversations, paper-based memos and reports, etc., policies, procedures, and plans. The ITs used include video conferencing, audio conferencing, audio messaging, wire transmissions, facsimile transmissions, electronic messaging, shared database access, application systems, and word processing.

Face-to-face meetings are any meetings between two or more collocated participants. Video conferences use television and computer technologies to simulate face-to-face meetings between participants who are not collocated.

Telephone conversations are between two individuals over the ubiquitous equipment of Alexander Bell. Telephone use can be supplemented, augmented, or replaced with several new technologies -- audio conferencing, audio messaging, and electronic messaging systems. Audio conferencing supports groups meetings using telephone equipment. Audio messaging is a technology that allows verbal messages to be recorded in lieu of a paper telephone message for an unanswered telephone call. Electronic messaging provides the capability of creating, sending, saving, archiving, and replying to automated messages.

Written coordination methods traditionally have been paper-based, typed documents that identify the policies, procedures and plans of each organization and its units. Other types of written media include memos, meeting agenda, reports, etc. Written coordination can be at least equivalently provided by electronic messaging (defined above), shared document processing, shared database access, wire transmission, facsimile transmission, and shared application access. Shared document processing refers to technologies to create, edit, save, archive, send, receive and monitor versions of text documents. It differs from electronic messaging in degree rather than kind; document processing provides more features and functions (e.g., lookup of documents based on a key word).

Shared databases refer to one or more interrelated files that are accessible, in a read-only manner, by multiple units. Actions against the database may include down-loading of data, ad hoc inquiry, or personal analysis and reporting.

A wire transmission is conducted via TWX, telex, or cable networks. A paper-based message is recoded in the electronic format for the specific network, then transmitted and retyped on paper. Wire transmissions combine typing (or word processing) with electronic transmission over public service networks. Facsimile transmissions use telephone technology to electronically transmit paper-based documents from one location to another. Shared applications automate detailed sequences of actions (i.e., procedures) required to complete some tasks.

3. BACKGROUND

Organizations are viewed as open systems that exchange resources with other parts of their environments (Katz and Kahn 1976). Different types of organizations vary in the work they perform and in their environments (Lawrence and Lorsch 1967). Environmental complexity and volatility determine the amount of differentiation needed to cope with the environment (Perrow 1970; Thompson 1967). As differentiation increases, organizations need more and more coordination to reintegrate interdependent units' work (Randolph 1977, 1980; Van de Ven, Delbecq and Koenig 1976).

A unit is composed of a group of individuals who collectively perform some unified organizational function. Organizational units can be viewed as micro-social systems whose functions resemble their parent organization (Van de Ven and Ferry 1980). Different units vary in the tasks they perform and in their environments (Lawrence and Lorsch 1967). At the unit level, the need for inter-unit coordination increases as unit interdependence for task completion increases (Randolph 1977; Van de Ven and Ferry 1980). Increasingly complex organizational designs² and methods of coordination³ can be used to manage the interdependence between units (Galbraith 1973; Katz and Kahn 1976; Van de Ven and Ferry 1980). The methods of coordination are important research topics because they are useful regardless of the organizational design mechanism. Thus, coordination methods, used alone or together, unify work across diverse units and are important to organizational existence (Cheng 1982).

Task characteristics of difficulty and variability (Perrow 1970) determine the type of coordination that predominates. The concept of difficulty is defined as the extent to which novel search activity is required to solve problems. Variability is the extent to which job tasks vary from day-to-day. As task difficulty and variability increase from low to high, the type of coordination changes. The coordination type ranges from predefined (for low difficulty/low variability tasks) to ad hoc (for high difficulty/high variability tasks) (Randolph 1977, 1980; Van de Ven and Ferry 1980; Van de Ven, Delbecq and Koenig 1976).

Figure 1 shows the traditional coordination methods used on a continuum from ad hoc to predefined types of coordination. For predefined coordination, written policies, procedures and plans have been the predominate methods found in organization research (cf. Randolph 1977; Van de Ven and Ferry 1980). For ad hoc coordination, verbal methods (i.e., face-to-face meetings and telephone conversations) predominate (cf. Randolph 1977; Van de Ven and Ferry 1980).

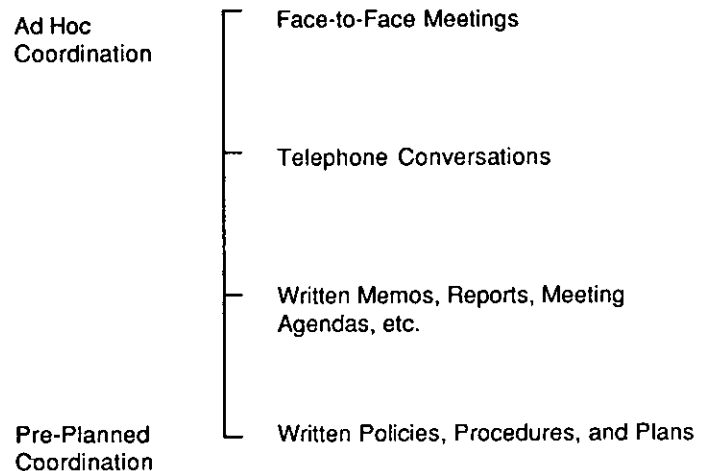


Figure 1. Traditional Methods of Coordination

Interdependence is the extent to which the work of the focal unit originates in other units, is jointly worked on with other units, or is independent of other units (Thompson 1967). The extent of interdependence relates to the amount of coordination rather than the use of specific methods. If

there is no interdependence between units, there is no need for inter-unit coordination.

The finding that written types of coordination will predominate for simple tasks and that verbal methods will predominate for complex tasks is consistent with theories that hypothesize coordination method selection based on the richness, or "potential information-carrying capacity of data" (Daft and Lengel 1984), bandwidth of the channel (Shannon 1948), or social presence (Short, Williams and Christie 1976). In general, these theories say that the richer the method used, the higher the number of channels used and the more information conveyed (Daft and Macintosh 1981; Davis and Olson 1985; Shannon 1948). Thus, richness is greatest for ad hoc coordination conducted in face-to-face meetings and decreases as coordination becomes indirect (i.e., conducted via telephone), and impersonal (i.e., written). Predefined methods of coordination are un-rich and use few channels of communication (Daft and Lengel 1984).

Even though in some cases there may be a best method of coordinating work, in many circumstances the methods of coordination are equivalent and interchangeable (Johansen, Vallee and Spangler 1979). These situations in which methods are equivalent, are of interest because different methods appear to predominate in different circumstances. The idea presented here is that different methods will predominate given appropriate task characteristics and influence from moderating factors.

The organization research presented above treats task characteristics as determinants of the predominant methods of communications (Randolph 1977; Van de Ven and Ferry 1980; Van de Ven, Delbecq and Koenig 1976). All coordination is one of two types: predefined or ad hoc (Randolph 1977). Method choice within type is either verbal or non-verbal. The importance of this work is the identification of predominating methods by coordination type. For predefined coordination, written methods predominate; for ad hoc coordination, verbal methods predominate. A limitation is that media choice and technology, in general, are ignored by this work. Media choice from among, for instance, face-to-face meetings and telephone is not explored. When ITs are considered, they are relegated to a simple, numerical role (Daft and Lengel 1984; Galbraith 1973). The increasing bandwidth of emerging technologies has shown that they can be used both to replace some use of

traditional methods for coordination and to support new interactions that would have not occurred without ITs (Picot, Klingenberg and Kranzle 1982).

The remaining research on coordination can be grouped into two broad categories: impact of IT and media choice. Both bodies of work support the conclusion that IT can and is used to coordinate work (Markus and Culnan 1987; Sumner 1986). Both bodies of work fall short of providing complete explanations for IT media choice. Research on IT impacts in organizations focusses on how technology changes the way work is done (cf. McKenney, Doherty and Sviokla 1986; Sumner 1986). This research assumes a technological imperative and ignores factors such as management choice, applicability of the technology, and task characteristics. Those researchers who have compared IT and traditional media choices have not used an exhaustive list of choices (cf. Lippitt, Miller and Halamaj 1982; O'Reilly and Roberts 1977; Sumner 1986). MIS researchers have generally ignored all traditional media except face-to-face meetings in media choice research (cf. Short, Williams and Christie 1976). Decreases in face-to-face meetings have been used to explain increased electronic media choices of new users, increased use of application systems, and increased use of electronic messaging systems (Markus and Culnan 1987). This research fails to explain how different tasks are affected; changes are treated as universal. The importance of this work is that it shows there are changes that can take place in the way work is done when ITs are introduced. The next step is to determine when changes occur and why.

Media choice research identifies the factors important to selection of methods for communications. This work concludes that cues present in face-to-face situations are helpful but not essential to effective communications (Short, Williams and Christie 1976). In mediated (i.e., computer-based) situations, participants compensate for absent cues with no measured impact on accuracy of decisions made (Short, Williams and Christie 1976). Many moderating variables have been posited as important to media choice including access, ease of use, cost, efficiency of method, training, and management support (Lippitt, Miller and Halamaj 1982; Markus and Culnan 1987; Picot, Klingenberg and Kranzle 1982). The major shortcomings of this work are that many studies are on new users (cf. Bikson and Gutek 1983; Hitt 1976; O'Reilly and Roberts 1977), or are laboratory based (cf. Short, Williams and

Christie 1976), which limits their generality. Analysis of results does not rule out other possible explanations; few studies have evaluated any relationship between task characteristics and moderating factors for ongoing users in the media choice problem (Markus and Culnan 1987).

Thus, task oriented coordination research identifies specific task characteristics that determine predominant forms of coordination. IT impact research provides a foundation for arguing that changes in organizational coordination do take place when ITs are introduced. Media choice research identifies possible moderating influences to the media choice problem but needs to include task characteristics as factors that predispose types of communication. All of this research is applicable to studies of coordination. The combination of task characteristics moderated by factors that support predominate use of either traditionally researched media or IT media is appropriate. Previous coordination research results identify the subset of methods that predominate when moderating factors do not support IT use. Further research on outcomes when moderators support IT use is required.

4. ELEMENTS OF THE PROBLEM

The variables in this study are:

- o Task characteristics
- o Media choices
- o Factors that influence media choice

4.1 Task Characteristics

Task characteristics related to media choice are interdependence (Thompson 1967) and complexity (Perrow 1970). Interdependence is the extent to which an organizational unit is dependent on some element (e.g., some other unit, company or organization) in its task environment. The amount of coordination increases as the extent of interdependence increases (Thompson 1967).

Complexity has two components: predictability and analyzability. Predictability is the extent to which a task contains variety (Perrow 1970). A low variety task is routine. A high variety task is non-routine and contains many exceptions that require decision making to complete the work. Analyzability is the extent to which a task is standardizable (Perrow 1970). Standardized tasks are well understood. Non-standardized tasks require

new behaviors to determine the appropriate response to exceptions during work. Predefined methods of coordination (traditionally policies, procedures and plans) are used to coordinate low complexity tasks (Randolph 1980). Ad hoc coordination increases as the degree of task complexity increases (Perrow 1970). For highly complex tasks, ad hoc coordination methods predominate.

In the present study, task characteristics were held constant in order to evaluate differences between traders' selection of coordination methods and the possible sources of those differences. During their interviews, traders were asked ten questions from the Van de Ven and Ferry (1980) Organization Assessment Inventory on complexity and interdependence. The responses were uniform in identifying trading as a complex and highly interdependent task.

4.2 Media Choices

Possible coordination media choices were defined in Section 2 and include face-to-face meetings, video conferences, telephone conversations, audio conferences, audio messaging, wire transmissions, facsimile transmissions, paper-based policies, procedures, and plans, document processing, electronic messaging, corporate database, public database, or computer-based application systems. Figure 2 updates Figure 1 with the addition of ITs on the continuum, based on MIS and media choice research. Each of the ITs and how each compares to traditional methods is discussed below.

Video conferencing has been used to replace face-to-face meetings (Short, Williams and Christie 1976). It has been found to be slightly less desirable a medium than face-to-face interactions (Johansen, Vallee and Spangler 1979; Short, Williams and Christie 1976) because it is less natural, more formal, and can be stilted due to limits of the technology (Picot, Klingenberg and Kranzle 1982). When compared to telephone use, video conferencing is perceived as more "personal."

Audio conferencing, audio messaging, and electronic messaging can replace, augment, and supplement telephone use through support of group telephone conferences, verbal messages, and transcripts of electronic exchanges, respectively (Johansen, Vallee and Spangler 1979). Audio conferencing lacks the visual cues of face-to-face meetings but overcomes the one-to-one limits of traditional telephone use.

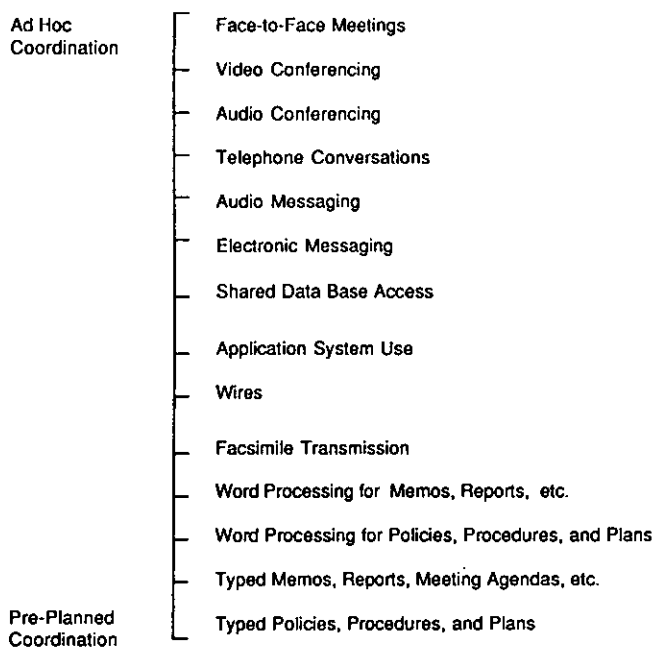


Figure 2. Traditional and IT Methods of Coordination

Audio messaging augments the content of written telephone messages by including the tone, pitch and emotion of voice messages. Electronic messaging augments telephone use by removing the need for simultaneous participation by users. It can support both interactive and asynchronous communications.

Shared databases are useful as coordination methods because they provide immediate access to inter-unit (or inter-organizational) information that units would otherwise have to obtain through other methods (e.g., memos or phone calls) (Galbraith 1973). Shared document processing has the capability to transmit documents, such as memos, electronically rather than via paper-and-mail manual processing. Multiple authorship, comments of reviewers, archival, retrieval, and document distribution are all capabilities of document processing technology.

Wire and facsimile transmissions provide faster information access than mailing a document while being lower in cost than a telecommunicated message. Applications can automate the policies, procedures, and plans, that comprise predefined coordination. In addition, applications can include

the compliance mechanisms that have traditionally been enforced by humans (Stewart 1971).

4.3 Factors that Influence Media Choice

The factors that moderate the choice of media from among traditional and IT methods fall into three categories: individual characteristics, technological characteristics, and organization characteristics. These categories are for convenience of discussion; this section outlines variables in each of these categories. This section also indicates the variables examined in the present study (which is reported in Section 7).

4.3.1 Individual characteristics

Individual characteristics include perceptions of ease of use of the media, skill of the individual in using IT, and the individual's knowledge of IT. When alternative media choices are available, people tend to use media perceived as easy to use and tend not to use media they perceive as difficult to use (Markus and Culnan 1987). Use of traditional methods of coordination is internalized in us as we grow. (Who can't use a telephone?) Until a generation of users also internalize IT use, and until ITs are universally perceived as easy to use, ease of use will be an issue. When perceived as a difficult alternative, choice of IT will be lower than competing traditional methods.

An individual's skill in using IT media is an important factor in the choice of that media. Skill is the ability to obtain desired information (Markus and Culnan 1987). For IT, this implies ability to enter the correct commands. For traditional methods, this implies the ability to organize a meeting, for instance. If IT skills are low, traditional methods will predominate in use.

Knowledge of the individual is related to skill. The person must know what information is available via IT and other media. If the user has no knowledge of electronic information available and how to access it, then other methods will be chosen. Frequently, knowledge is transmitted through training, which is discussed below.

4.3.2 Technological characteristics

Characteristics of the technology include perceptions of speed of access, efficiency of the method, cost of the method, documentation, training

and technical support. The first three of these factors -- speed of access, efficiency and cost-- define the extent to which IT media are perceived by the users to be at least as attractive as traditional media. IT use will predominate as user perceptions of IT speed increases, efficiency increases, and cost decreases relative to other media (Strassman 1985).

The availability of documentation, training and technical support have been identified as important to implementing new technologies in organizations (Robey and Markus 1987). The present study does not include new users. These factors may be less important to ongoing use; they are included here because they are usually omitted from studies of ongoing use of IT.

4.3.3 Organizational characteristics

Organization variables identified as important to use of IT are access, senior management support, immediate manager support, peer support, and organizational support (Bikson, Stasz and Mankin 1985; Lippitt, Miller and Halamaj 1982; Markus and Culnan 1987). Each of these variables is discussed in this section.

Support from senior management, the user's immediate manager, peers, and the organization are important to use of IT (Bikson, Stasz and Mankin 1985; Lippitt, Miller and Halamaj 1982). Support from managers can include both encouragement to use media and actual use of media. Peer support lies in the use of a medium. Organizational support for usage of media is evidenced in inclusion of IT in strategy statements, business plans and job descriptions. All of these types of support are included in this study.

Access is the availability of hardware, software and data to users for the performance of their jobs (Markus and Culnan 1987). Access is discussed as an organizational variable because availability results from management decisions about equipment expenditures, type of software to provide and security precautions over data access.

To summarize this section, skill in retrieving desired information, knowledge of media availability, management use, peer use, and perceptions about media ease of use, effectiveness, cost, efficiency, speed of access, and management support are all important factors that are expected to moderate the

choice of coordination method. When the user ranks each of these variables as high, the use of ITs for coordination are expected to predominate. When users rank each variable as low, the use of traditional methods of coordination are expected to predominate.

5. THE RESEARCH QUESTIONS

The model to be evaluated incorporates coordination and IT research to develop a new perspective on how IT can replace traditional methods of coordination. Figure 3 shows task complexity and interdependence as determinants of coordination methods which predominate based on past research. For simple, interdependent tasks, written methods predominate; for complex, interdependent tasks, verbal methods predominate (Van de Ven and Ferry 1980).

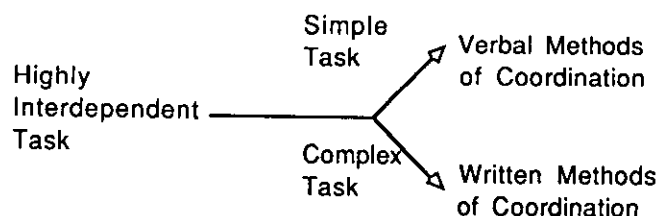


Figure 3. Model of Coordination from Organization Theory Research

Within each predominating type of coordination, the selection between traditional and IT methods is moderated by the extent to which the variables discussed in the previous section facilitate the use of IT. These relationships are shown in Figure 4 for simple tasks and complex tasks. Only complex tasks are evaluated in the present work.

It is expected that differences in IT use occur for different tasks types. ITs that are at least functionally equivalent to the traditional methods of coordination should be found. For complex tasks, shared database access, audio conferencing, audio

Task		Face to Face	Video Conf.	Audio Conf.	Telephone Call	Audio Message	Electronic Message	Shared Data Base	Application System	Wire Transmissio	Facsimile	Word Processing	Typing
Complex	Ease of Use	High	N	Y	Y	N	Y	Y	Y				
	Skill	High	N	Y	Y	N	Y	Y	Y				
	Knowledge	High	N	Y	Y	N	Y	Y	Y				
	Org. Support	High	N	Y	Y	N	Y	Y	Y				
	Management Support	High	N	Y	Y	N	Y	Y	Y				
	Access	High	N	Y	Y	N	Y	Y	Y				
	Speed/Access	High	N	Y	Y	N	Y	Y	Y				
	Efficiency	High	N	Y	Y	N	Y	Y	Y				
	Cost	Low	N	Y	Y	N	Y	Y	Y				
	Documentation	Avall	N	Y	Y	N	Y	Y	Y				
Simple	Ease of Use	High							Y	Y	Y	Y	N
	Skill	High							Y	Y	Y	Y	N
	Knowledge	High							Y	Y	Y	Y	N
	Org. Support	High							Y	Y	Y	Y	N
	Management Support	High							Y	Y	Y	Y	N
	Access	High							Y	Y	Y	Y	N
	Speed/Access	High							Y	Y	Y	Y	N
	Efficiency	High							Y	Y	Y	Y	N
	Cost	Low							Y	Y	Y	Y	N
	Documentation	Avall							Y	Y	Y	Y	N
Training	Yes							Y	Y	Y	Y	N	
Tech. Support	Yes							Y	Y	Y	Y	N	

Figure 4. Moderator Variable Effects

*Y indicates an IT method of coordination that will predominate when the condition prevails. N indicates a traditional method that will predominate when the condition is the opposite value.

messaging, and electronic messaging should predominate because those functions have been dominated by face-to-face meetings and telephone conversations. For simple tasks, applications and document processing should predominate because those functions have been dominated by paper-based policies, procedures, and plans. The case was an evaluation of complex tasks to identify specific hypotheses for empirical work. The hypotheses generated from this work are presented in the conclusions, Section 8.

6. METHODOLOGY

This section describes the selection of case sites and procedures for the case studies.

6.1 Selection of Participating Organizations

Service firms were chosen because they employ the majority of the work force and because they represent an under-studied segment of business (Bell 1979). Financial service firms were selected from

all service firms as having a broad base of IT installed (Vyssotsky 1979). Five large, heterogeneous organizations in the New York area which span similar sectors of the financial services industry were identified from the *Fortune* "Service 500." From the five organizations identified, two firms were selected as a convenient sample. The two firms were closely matched in terms of the services provided. Both firms had been in business over 100 years. Both were very stable, organizationally and in terms of product mix, until the late 1960s. Both have experienced rapid growth, diversification, and expansion into new business areas since then. The firms identified each other as major competitors. Both firms had equity trading departments in different subsidiaries that served different constituents (this is discussed below). Both companies were highly decentralized with the parent organizations exercising little direct control over subsidiary activities.

Letters of introduction were sent to managers of the equity trading departments in each subsidiary. Appointments to discuss the research provided entry to the organization. For the two organizations, five equity trading departments, one in each of five subsidiaries, were included in the study. Equity trading was selected as an example of a complex task because the tasks are highly variable and complex, with frequent changes in market conditions to which the trader must adapt.

No attempt was made to vary task characteristics; rather, definition of equity trading as a complex, interdependent task was confirmed. The goal was to identify which ITs were used by traders, to find differences in the use of ITs across equity traders and to identify the sources and/or contributing factors to those differences. No linkages between the task characteristics and either the media choices or moderators were done.

Of the five subsidiaries, three are portfolio management (PMOs) and two are public trading (PTOs). In PMOs, traders do not deal directly with the public. Portfolio managers, who have fiduciary responsibility for the holdings of a client (e.g., the pension fund of company XYZ), generate buy and sell orders based on their own judgement. PTOs are organizations in which traders do deal with the public. Traders (also called salesman/traders or account executives) generate buy and sell orders through sales calls to clients.

A total of thirteen traders were included in the study. Eight traders were from PMOs (out of fourteen total PMO traders); five were from PTOs (out of 140 total PTO traders). Four equity trading managers and two trainees were included in the observations; their jobs were the same as the traders observed. By comparing equity traders across the subsidiaries, differences in the use of coordination methods and relationships between the moderating and independent variables were identified for further testing.

6.2 Procedures for Data Collection

Data collection proceeded over several sessions. Initial interviews were conducted with the manager of each equity trading unit. The purpose of the interviews was to collect information about organization structure, breadth of tasks in the department, the conduct of coordination between this department and other departments and/or organizations, the locus of decision making for selecting IT services, etc. Further interviews were held with the traders who were observed to obtain their self-ratings on the moderator variables and to discuss how they approached their jobs. Interviews with data processing staff were conducted to obtain information about the systems, functions, training, and support available in the organization. All interviews consisted of open-ended and semi-structured questions. The questions on task characteristics and interdependence were developed by Van de Ven and Ferry (1980) for the Organizational Assessment Inventory. The other questions were developed specifically for this study.

Work of thirteen traders was observed for periods ranging from four to fifteen hours each. The purpose of the observations was to identify and tabulate coordination acts and to cross-check interview results with actual data. Coordination must be differentiated from task performance on a job by job basis. Traders jobs, at the most elemental level, included the issuance of a trade order to a broker, the order to execute a trade, and the negotiation of commissions. These tasks *were not* tabulated as information coordination acts. The acts of coordination that traders performed included:

- o Obtaining trade orders from PMs or customers
- o Confirming trade accuracy via written comments on computer reports

- o Completing trade tickets or data entry on trades that they completed that day
- o Identifying large block trades (over 10,000 shares) to the Autex network (as required by law)
- o Getting information throughout the day on market conditions that inform their decisions

These activities qualified as coordination acts because they helped the trader time and prioritize his tasks. Obtaining orders is generally via face-to-face or telephone interactions. Morning coordination meetings were held in all organizations to ensure concerted actions. In PMOs, trade orders are collected for all portfolio managers and sorted by stock. The orders are given to the equity trading manager at the morning coordination meeting. Changes to buy/sell orders can occur during the day but are infrequent. In PTOs, traders receive all orders from clients. Changes to buy/sell orders can occur at any time depending on the wishes of the client. PTO traders have more interactions with clients throughout the day (as many as 25 for one trade) than PMO traders have with portfolio managers (usually one or two status checks on all trade orders).

Confirmation of trade accuracy was required by traders for the operations staff to complete their jobs. Confirming trade accuracy was generally written unless there is a problem, at which time telephone and face-to-face interactions occur. Trade ticket completion was hand-written while data entry was via an application system. Obtaining information throughout the day was via face-to-face telephone, public and corporate databases.

The traditional coordination methods and applications need little justification. The use of databases as a method of coordination, however, is a fairly novel concept. Before shared databases, before Quotron, and even before the telephone, runners were used as the method of coordinating trade information between remote sites and the stock exchanges. People acted as coordinators. With the invention of the telephone, many of the runners' activities were replaced with phone calls. With Quotron and the Videoquote systems, runners were eventually replaced with information piped directly from the exchange's clearing house. Now, there are over 100 different information services available to workers in the financial services industry (e.g., buy/sell brokers, trends and activity for individual equities, up-to-the-minute announcements of buy/sell

recommendations). Most traders have access to several (usually less than ten). Thus, databases, in the form of publicly available information services can be used as coordinating devices by providing information to assist traders in prioritizing and sequencing trade actions.

Actions of traders were defined as information coordination (getting or giving information needed to perform work) or other (not tabulated). No counts were kept for personal conversations, non-task related conversations, actual buy/sell order placement or order activation. Activities counted as coordination acts included incoming/outgoing phone calls, shared database requests, face-to-face meetings with people from other departments, meetings with people in the same department, and paper in/out. The content of these activities was confirmed as one of the five listed above by the researcher. The traders were asked to classify activities when there was a question about its applicability.

The services accessed included public databases or corporate databases (e.g., PM history, client history, stock history, etc.). Every trader had access to either the Quotron or Shark networks for up-to-the-minute stock market status. These systems allowed users to customize the screen listing 80 to 120 stock market measures (e.g., the Dow-Jones average) and specific stock prices. Each item on the screen was updated at least once per minute with many updated approximately every five seconds. These changes were not counted as part of the CRT changes made by traders. The traders also obtained information about specific stock prices by entering commands; trader initiated access to these and other services were counted in this report.

Acts of coordination were counted for five minute intervals. For an interval, the predominate method was the one with the most activity. The number of intervals in which each method predominated were counted and compared to determine the overall predominate method of coordination.

Traders were asked questions about how they did their jobs to verify that, within a subsidiary, there would be differences between the traders' use of services. The questions were developed for this study and included both open-ended (e.g., "Tell me about the process of selecting and installing new information services.") and close-ended questions

(e.g., "Do you have any say over what information services you use?" This was followed with "How much?" and "Give an example."). Occasionally the traders had not previously thought about what was asked and more probing was required. For instance, two traders (both with PTOs) were stumped by questions about "what process you follow in deciding to execute a trade." One answered, "I don't examine it, I just do it." A walk-through of her mental processes for a recently completed trade identified this trader's internal protocol. That discussion led her to talk of differences for other stocks, market conditions, busy/slow periods, etc.

More often, the traders knew why they used a given service and how it helped them in their jobs. One trader explained his use of the public databases.

Using the ITW trade as an example, if a trader is not familiar with a stock, they gather as much information as possible to form an opinion. For instance, the Bridge system gives a quick rundown on the liquidity of the stock and the possible risk through information on Price/Earnings ratio, support/resistance price levels, technical charts of the last two months' trades, and a summary by day of the last two weeks of trades.

ITW's PE is around ten, which is good. The support/resistance range is narrow, between 50 and 60 and for the last two weeks it has been trading steadily in a one or two point range higher every day. Nothing dramatic but nice movement. Contrast this XYZ stock which has similar financial information but which is trading more erratically. It spikes one day and is up and down every three or four days. I wouldn't buy this stock.

Back to ITW, then I might look at Autex to see who is buying and selling. (He changed the screen.) There are ten people in the market. Two buying and the rest selling. Next, I want to know how many of the sells are real. I know that WWW Company isn't real; they're there to fish the market. MMM Company is there three times; they are real and they have three lots that are pretty big. Now look at Quotron at the same time (on the other

screen). See the price is four, down from 4 3/4 at the open. Now you know why they went out of town on this one (to get a higher price than bid in the NY market). So, this one we win.

Traders were also asked specific questions about the moderator variables. All questions were developed for this study. An example for management support is: "Does your immediate manager encourage the use of ITs in your job?" Questions were framed to obtain yes/no responses. Follow-up questions were asked to determine the strength of "yes" responses (e.g., "How often does your manager encourage use of ITs? How do you know he encourages their use?").

7. RESULTS

In this section, how coordination is accomplished by equity traders is discussed. Statistics used to develop the hypotheses are presented. The relationship of moderator variables to inter-unit coordination by equity traders is analyzed.

7.1 Coordination

All methods of coordination, except video conferencing, were available in at least one organization. Only two (PMOs) of the five subsidiaries used electronic messaging and audio messaging. In general, the telephone and computer connected the traders to their world. For a day, the average number of interactions per trader was astonishing:

- 284 (Business) Phone calls
- 257 Screen changes (includes only trader initiated screen changes)
- 26 Inter-unit face-to-face meetings
- 12 Paper information inputs (Ompits Buy/Sell Tickets of manual firms)
- 622 Intra-unit face-to-face exchanges (usually telephone messages).

During the trading day (9:30 a.m. to 4 p.m.), traders process about one transaction each fifteen seconds. This statistic was stable across all traders regardless of whether they considered themselves "verbal and human" or "electronic junkies."

Trader ID	Total		Predominate		Method		of Coordination		Intra-Unit		No One		Method	Row
	Number	CRT	Phone	Inter-unit	FIF	Paper	FIF	Paper	FIF	Paper	Predominated	Total		
	Intervals	N	Percent	N	Percent	N	Percent	N	Percent	N	Percent	N	Percent	Total
AM	80	60	75.0%	5	6.3%	6	7.5%	6	7.5%	3	3.8%	0	0.0%	100.0%
A1	76	21	27.6%	40	52.6%	6	7.9%	6	7.9%	3	3.9%	0	0.0%	100.0%
A2	42	18	42.9%	15	35.7%	0	0.0%	6	14.3%	3	7.1%	0	0.0%	100.0%
B1	77	16	20.8%	52	67.5%	0	0.0%	6	7.8%	3	3.9%	0	0.0%	100.0%
B2	78	12	15.4%	57	73.1%	0	0.0%	6	7.7%	3	3.8%	0	0.0%	100.0%
BT	79	5	6.3%	65	82.3%	0	0.0%	0	0.0%	6	7.6%	3	3.8%	100.0%
CM	66	48	72.7%	11	16.7%	3	4.5%	0	0.0%	2	3.0%	2	3.0%	100.0%
C1	56	44	78.6%	8	14.3%	0	0.0%	0	0.0%	4	7.1%	0	0.0%	100.0%
DT	52	22	42.3%	13	25.0%	8	15.4%	4	7.7%	3	5.8%	2	3.8%	100.0%
D1	92	55	59.8%	21	22.8%	8	8.7%	3	3.3%	3	3.3%	2	2.2%	100.0%
D2	91	54	59.3%	23	25.3%	11	12.1%	0	0.0%	3	3.3%	0	0.0%	100.0%
E1	40	6	15.0%	8	20.0%	11	27.5%	3	7.5%	6	15.0%	6	15.0%	100.0%
E2	21	3	14.3%	6	28.6%	4	19.0%	3	14.3%	5	23.8%	0	0.0%	100.0%
	850	364	42.8%	324	38.1%	57	6.7%	43	5.1%	47	5.5%	15	1.8%	100.0%

Figure 5. Equity Trader Coordination Method Use

Use of the telephone and shared database access (called CRT changes on the chart) together predominated, accounting for about 81% of 850 five minute intervals (see Figure 5). The other 19% of intervals were split about equally between inter-unit face-to-face paper, and intra-unit face-to-face interactions. None of the other interactions was large enough to be near .5%.

Overall, CRT changes by the traders predominated for 42.8% of the intervals. The traders in this report averaged one screen per five minute interval all day. Peak access was at the beginning and end of the day, during which the average ranged from 15 to 30 accesses per trader per five minute interval. Three sites provided corporate databases to provide holdings information for individual stocks, history of trades by portfolio and by stock, etc. Two sites used online application systems for recording trade information. Portfolio managers' order slips were summarized on 8x14 sheets that each hold information on 25 orders -- the name, total shares to be traded, accounts to charge and number of shares per account, commission, and transaction bank. The orders are the only paper-based material the traders deal with in the two fully automated firms.

Each trader had access to at least four different information sources -- purchased database access or corporate database access. Each trader was asked about their discretion in the choice of sources they used. In PTOs, the traders selected from a range of four or five services offered within the company and generally used only one or two of the services.

In PMOs, the traders participated in evaluating services and actually decided which they would use. During the day, all traders had complete discretion over which services they used at any given time. No trader was aware of pressure to use computers; several cited managers who warned of relying too heavily on the equipment. Several of the traders described themselves as "touchy-feely" and "human," and as more likely to rely on human interaction than electronic information. These traders liked to "feel" the market through the speed and noise of the overhead Quotron tape.

Telephone use predominated for 38% of the intervals. Extensive use of the telephone for monitoring trade status and obtaining information was the other major method of coordination. Traders were on the phone almost continuously from the time they began work until they left. The average phone call lasted fifteen seconds. Telephones are the second most heavily used information sharing tool that traders use. But, telephone use was heavily concentrated in two peak periods -- 9:15 to 9:45 a.m. (the market opening) and 3:40 to 4:10 p.m. (the market closing). In the time from 9:15 to 9:45 in the morning, several traders made over 50 phone calls. If those two peaks are omitted from the analysis, shared database access is used significantly more throughout the day.

A morning coordination meeting was held in each site to announce large trades in PTOs, to announce all buy/sell stocks in PMOs, and to give everyone an opportunity to hear research reports, reports on trade conferences, to discuss the day's expected

activity, etc. Face-to-face coordination also took place in the form of frequent visits to the trading room for information exchanges by portfolio managers (PMs).

The three subsidiaries with manual trade processing used paper trade tickets to pass information to other units involved in trade processing. These sites used paper trade tickets with time stamps to confirm trades. The tickets were routed to other departments for coding, editing, data entry, and reconciliation. Computer print-outs of the previous day's trades were one of the paper forms of coordination from other departments that traders received. The traders marked the listings with error corrections and returned a signed copy of the reports as confirmation of their review.

Little paper was used in the job. Memos were rare. Written telephone messages were used occasionally in one organization and not at all in any of the other organizations. Written reports were incoming only and tended to be research analyses of stocks. One large trading group recapitulated morning activity by circulating copies of a hand-written list of large blocks of stock traded. Electronic mail was used in one firm but the traders only read mail, they never responded to it. Word processing was used in all firms but rarely in support of trading activity.

7.2 Moderating Influences

Each trader was asked to rate his/her job with respect to each moderator variable. The results for support from different levels of management, perceived ease of use, perceived skill level, and perceived knowledge are shown in Figure 6.

Each of the four variables distinguished between high and low ratings for the moderator variables and the predominant method of coordination. For each variable, when there was high support for IT use, shared database use predominated. When there was low support for IT use, telephone use predominated. These results lend support to the notion that when moderator variables support IT use, IT methods of coordination will predominate.

For peer support, speed of access, efficiency of the method, cost of the method, documentation, training and technical support, the results were not different across the traders to provide any comparative information. For several of those variables, only

one trader had a low score, so no analysis was done.

Peer support was evaluated in terms of how many peers used the same ITs and how much pressure the trader felt to use IT to compete in his/her industry. When asked about the need to compete in the industry, traders all gave similar answers. They felt that their competition was in terms of "the numbers" on how much money their clients made in PTOs and how well they performed relative to other traders for PMOs. As long as the goals of their clients (in PTOs) and organizations (in PMOs) were met, there were no questions asked about how much traders used or did not use IT.

	1	2	3
1	Predominate Method of Coordination		
2	for Moderator Variables		
3	Management Support		
4		High	Low
5	Phone	29% (126)	80.3% (188)
6	Crt	71% (306)	19.7% (46)
7	N of Traders	8	5
8			
9	Perceived Ease of Use		
10		High	Low
11	Phone	37.9% (154)	61.5% (160)
12	Crt	62.1% (252)	38.5% (100)
13	N of Traders	8	5
14			
15	Perceived Skill Level		
16		High	Low
17	Phone	39.9% (162)	62.8% (152)
18	Crt	60.1% (252)	37.2% (90)
19	N of Traders	9	4
20			
21	Perceived Knowledge		
22		High	Low
23	Phone	29.5% (124)	77% (190)
24	Crt	70.5% (296)	23% (56)
25	N of Traders	8	5
26			
27			

Figure 6. Effects of Moderator Variables

Speed of access, efficiency of method, and cost of method all had similar results. The traders were more concerned with obtaining specific desired information than with cost. Speed and efficiency were perceived as high "because it's on a computer." One trader said that the major bottleneck to market performance was "not computers, it's people. We are at our limit of information processing."

Training, when it was provided, was by vendors during installation and on the job, by peers thereafter. All traders were expected to "pick up" the use of ITs available. All pointed to volumes of documentation on the services, had their own "cheat sheets" of commands to which they referred, and had no other means of support.

8. CONCLUSIONS AND FUTURE WORK

This work shows that IT can be a predominate method of coordination for the highly interdependent and complex task of equity trading. The results support the hypotheses that the type of coordination that predominates would be verbal, direct, or ITs providing equivalent functionality. The moderator variables of management support, perceived ease of use, perceived skill level and perceived knowledge lend support to the notion that moderators may influence which methods of coordination predominate.

From the results, specific hypotheses for future testing were developed for highly interdependent and complex tasks.

H1: For a *high* level of task complexity, the methods of coordination that will predominate include face-to-face meetings, audio conferencing, telephone use, shared database use, and electronic messaging.

H2a: For a *high* level of unit task complexity, when moderating variables *support* IT use, shared database, audio conferencing, audio messaging, and electronic messaging use will predominate. (See Figure 4.)

H2b: For a *high* level of unit task complexity, when moderating variables *do not support* IT use, face-to-face meetings and telephone use will predominate. (See Figure 4.)

Similar hypotheses can be generated for simple tasks; the larger study of which this case is a part

includes such hypotheses. This research, while promising, is too limited in scope to test hypotheses. It is useful in the development of specific hypotheses for future empirical work. The task of equity trading was verified as highly complex and interdependent. Research including more participants, different types of work (i.e., combinations of high/low complexity and high/low interdependence) and organizations with other types of coordination methods in use are all examples of necessary further research.

An extension of the hypotheses to include efficiency and perceived effectiveness of the use of the predominating methods is also warranted. A research area related to equity trading that appears warranted is a test of the extent to which the number and type of IT services and databases used impacts on the actual performance of the traders.

The inclusion of individual differences in IT use as a potential mediating variable also seems warranted since some of the traders described themselves as "high-tech" and "a touchy-feely guy...not a computer guy." There were too few participants to evaluate individual differences in this work.

The overall conclusion of this work is that IT can be and is used for inter-unit coordination in one type of highly interdependent, complex task. Equity traders used shared database access for information gathering more than any other method. The use of shared databases was even more dramatic when specific moderating influences were measured. ITs in equity trading are used in harmony with telephone and other methods of coordination. Hypotheses, supported by the results, were generated for future testing. More case research and empirical research are needed to better understand IT use for coordination.

ENDNOTES

¹ Information technologies are computer-based communications and computing techniques.

² For example, definition of self-contained tasks, use of coordinators or coordinating groups, etc. (Galbraith 1973).

³ For example, rules, policies and procedures; plans, schedules, and forecasts; information systems, etc. (Van de Ven and Ferry 1980).

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