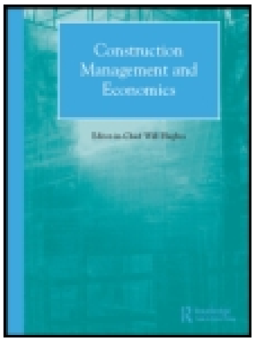

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Organizational structures in the construction industry

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The links between the theoretical issues influencing the structure of construction project organizations are discussed. The impact of the environment of a construction project and the technological sophistication of the project are considered in terms of how these factors shape project organizations. The environment is variously assayed for its complexity, its dynamism and its hostility. The technology used in projects is assessed by its level of certainty (whether it is well understood), its complexity and the level of interdependence between subactivities in the project. The variables are used to formulate hypotheses concerning their impact upon the structuring of construction projects and these are studied in 18 case studies. The research has been developed within an interpretive (phenomenological) paradigm. The findings suggest that complex environments lead to greater decentralization of authority, mainly by delegation. In the dimension of technology, complexity led to a wider use of liaison devices on projects with a greater number of technical functional specialists being used by projects. As projects become more technically interdependent then informality and flexibility are the principal mechanisms of project control.

Keywords: Organizational structures, environment, technology, project management.

Introduction

One of the critical tasks of senior staff in construction organizations is to design project organizations which are suitable for a particular project environment. In the construction industry the organizational patterns have to take account of the need for subcontractors or specialist contractors working together and the organizational structure of a project can shape the nature of these intrafirm relations and the way people involved in construction projects are organized. The process of developing an appropriate organization structure has its roots in organizational theory dating back to the late 1940s. More recent developments in organizational design have focused upon the process of achieving a coordinated effort through the structuring of tasks, authority and work flow. Such efforts are a conscious process to develop the most effective and stable patterns of interaction between firms which operate within the project organization. The result is an organization structure which links technology, tasks and human components through formal and semi-formal means to ensure the accomplishment of project objectives. Mintzberg's (1979) analytic approach to studying the structure of organizations was to break the essential parts into four main groups or design parameters; position, superstructure, lateral linkages and decision making systems. However, this prescriptive approach has been questioned by researchers in construction management (Morris, 1983; Newcombe *et al.*, 1991), who have seen the systems approach as one more suited to the construction industry. In particular the concept of an open system has become a popular model with which to conceptualize a construction firm or project which interacts with the environment in which it operates.

Morris (1972) also saw the key priority for increasing the effectiveness of the construction process to lie in the management of the dynamic interrelationships between various organizations found on a building project. The main area of difficulty is identified as the interdependence of design and construction and, hence, the emphasis is placed on the investigation of the patterns of coordination and control at the design–construct interface in different conditions of uncertainty and complexity. Morris (1972) stated that where there is uncertainty and complexity it will be helpful to design semi-autonomous organizational subsystems and to concentrate one's managerial attention on their interrelationships. However, this can produce highly fragmented subsystems on each side of the interface which would require more information processing for effective integration.

Morris proposed two ways of resolving this problem. The first involves rearrangement of the ordering and positioning of subsystems and their interrelations. The second concerns the usage of various integrative methods depending upon the structural differentiation of the subsystems. Speed was identified as a critical factor in influencing coordination and control, since it affects the degree of overlap between design and construction and the amount of reciprocal interdependence between functions. To handle the cross-over between the two stages, contractual arrangements encouraging early entrance of the contractor onto the project is suggested to be vital for adequate appraisal of design implications on the project programme.

Tatum (1983) used prescriptive and descriptive models distilled from decision making theory to analyse data regarding how managers design project organizations. His objective was to provide knowledge about current practice to see whether it needs to be preserved or modified. The conclusions indicate frequent adaptation of past structures, particularly when urgent situations force quick decisions. When data regarding the situation are available and time allows, decision making involves greater analysis and moves towards the contingency view.

Tatum (1983) recognized that varying situations such as progression through the project life cycle, performance difficulties and changes in project goals demand a series of decisions regarding the appropriate configuration of structure. Therefore, relying heavily on the ideas presented by Thompson (1967), Tatum (1983) proposed a framework as a starting point for systematic decision making to custom design an organization according to specific project requirements. The proposed structuring process contains eight steps: define project objectives and set priorities, define line management organization, provide appropriate means for coordinative tasks, decide level of staffing and size of each unit, design staff groups, add planning and monitoring systems, locate decision making and delegate authority and, finally, define requirements for positions. Although the contractor's organization is considered as the unit of analysis, Tatum (1983) also referred to the importance of external influences and the need to locate the staff groups adjacent to the line segments for direct interaction and to buffer the operating core from environmental disturbances.

Bennett and Fine (1980) in relating current organizational theory to the construction industry emphasized the importance of the industry's distinctive features of fragmentation and temporary coalitions of specialist firms with sometimes divergent economic and social interests. In response to the requirement of creating a unique organization composed of individuals and groups drawn from a selection of various firms, the stated objectives are better achieved through an appropriate choice of contactual arrangements and project delivery systems. Bennett and Fine (1980) expanded upon this macroscopic view to include in his theoretical premise that the choice of organization should be based on the analysis of the construction process, which is considered as a link between the project organization and the tasks performed. A simulation model is introduced to measure the effect of variations in size, production technology and predictability of the task, as major determinants of process, on the changes that can occur in the cost and duration of site activities.

This move towards open systems analysis has produced a swing towards contingency or situational design of organizations. This contingency view, emphasizing a complex interaction between the environment, the task, technology, human motivation and organizational structure, suggests that there is no one best way to organize or manage a construction organization or project. Previous research has examined various contingency variables in structure. Bryman *et al.* (1987) discussed the concept of 'transience' on the Least Preferred Co-worker (LPC)–project performance relationship and concluded that the length of a project could well have an impact on relationships.

Bresnen (1990) offered a scholarly discourse on organizing construction. In this work he described organizational structure as being dependent upon combinations of external and internal variables. The external factors such as resources, information, specializations are embodied in the terms and conditions of contract which play a central role in organizational structuring. The internal factors are combined with the external issues where construction organizations operating in competitive environments tend to tighten up their operational and administrative procedures. Firms operating in hostile contractual environments may be seen to structure project organizations to create buffers between the external environment and the project.

The pervading research since the 1980s has been a quest for an understanding of how various parts of a project organization interact to encourage effectiveness in project management. Nahapiet and Nahapiet (1982) saw three clusters of attributes shaping project performance: client attributes, project delivery processes and environmental conditions. Success was generated by effective management of the interfaces between interdependent subcontractors.

Winch (1988), using a sociotechnical systems approach, argued that all organizations have a technical system comprising of work processes serviced by the social systems of personal and group interaction. In construction, these systems operate within single organizations but also across the boundaries of the firm. This need for unification of systems across a construction project leads to project management seeking to stabilize environmental and technological uncertainty. One response to such uncertainties is for companies to combine centralized project reporting systems and a series of delegations of authority. These systems are unified across the construction firm and project managers are given delegated authority to manage the technical process.

A synthesis of these views would identify that the theorists have seen some common factors in organizational design. Woodward (1980) noted that technical methods were the primary factor in determining organizational form. This view was broadly supported by the work of Burns and Stalker (1961) who illustrated how different rates of change of product line (brought about by different levels of environmental uncertainty) call for different organizational designs and differentiated mechanistic from organic structures. They argued that firms operating in stable environments impose quite different structural requirements to those operating in a more complex and rapidly changing environment. Lawrence and Lorsch (1967) continued to popularize the contingency view with their study of the structure and functioning of organizations in stable and dynamic environments. The linkage between technology and organizational structure is not universally recognized and Thomas *et al.* (1983) saw technology as only one of nine factors influencing a project management authority structure. Thomas *et al.* (1983) argued that where there is technological uncertainty characterized by the use of dynamic and unstable technology then functional organizational structures need to be applied where authority is decentralized to the project. If authority is centralized to the head office then a matrix or project form (where the head office-based project manager has total authority) is most appropriate.

In this work the researchers focused on two key variables in the structuring of construction project organizations – the environment in which the project operates and the technical system or level of technology associated with the project.

The concept of the environment

Duncan (1971) defined environment as the interaction between the system's internal and external components. This consists of those relevant physical and social factors inside or outside the boundaries of the organization that have direct influence on the decision-making behaviour of individuals and decision units (a list is shown in Table 1). In order to make predictions about the kinds of environments in which different levels of perceived uncertainty are expected to exist and their consequent structural demands, Duncan (1971) identified two dimensions of environment which are represented along two continuums of simple–complex and static–dynamic.

The simple–complex continuum deals with the degree to which the components of environment influencing the decision situations are few in number and similar in nature or are many and different. The static–dynamic continuum indicates the degree to which the components remain basically the same over time or are in a continual process of change. Figure 1 provides a four-

Table 1 Factors and components comprising the organization's internal and external environment (Duncan, 1971)

Internal environment

1. Organizational personnel component
   - (a) Educational background and skills
   - (b) Previous managerial skills
   - (c) Interpersonal behaviour skills
   - (d) Availability of manpower for utilization within the system
2. Organizational functional and staff units component
   - (a) Technological characteristics of organizational units
   - (b) Interdependence of organizational units in carrying out their objectives
   - (c) Conflict among organizational, functional and staff units
3. Organizational level component
   - (a) Organizational objectives and goals
   - (b) Nature of the organization's product/service

External environment

1. Customer component
   - (a) Distributors of product or service
   - (b) Actual users of product or service
2. Suppliers component
   - (a) New materials suppliers
   - (b) Equipment suppliers
   - (c) Labour supply
3. Competitor component
   - (a) Competitors for suppliers
   - (b) Competitors for customers
4. Sociopolitical component
   - (a) Government regulatory control over industry
   - (b) Public political attitude towards industry and its particular product
   - (c) Relationship with trade unions
5. Technical component
   - (a) Meeting new technological requirements in production of products or services
   - (b) Improving and developing new products and methods

Static	Cell 1: low perceived uncertainty (1) Small number of factors and components in the environment (2) Factors and components are somewhat similar to one another (3) Factors and components remain basically the same and are not changing.	Cell 2: moderately low uncertainty (1) Large number of factors and components in the environment (2) Factors and components are not similar to one another (3) Factors and components remain basically same
Dynamic	Cell 3: moderately high perceived uncertainty (1) Small number of factors and components in the environment (2) Factors and components are somewhat similar to one another (3) Factors and components of the environment are in a continual process of change	Cell 4: high perceived uncertainty (1) Large number of factors and components in the environment (2) Factors and components are not similar to one another (3) Factors and components of environment are in a continual process of change

Figure 1 Four-way classification of environment and perceived uncertainty experienced by individuals in decision units.

way classification of organizational environments. Complex–dynamic (cell 4) environments are probably the most characteristic type of environment in the construction industry involving rapid change and unanticipated decision situations (see Crichton, 1966; Thompson, 1967).

Many researchers have tended to combine the two dimensions together, since they often move in tandem and so have been unable to distinguish their individual effects on structure. In this research, Duncan (1971) was able to show that, at least in terms of managerial perceptions, the two dimensions are distinct and uncertainty in decision making is related to the dimension of stability rather than complexity. Duncan (1971) stated that 'The static–dynamic dimension of environment is a more important contributor to uncertainty than the simple–complex dimension. Decision units with dynamic environments always experience significantly more uncertainty in decision-making regardless of whether their environment is simple or complex' (Duncan, 1971, p. 313).

The concept of technology

Although the literature does not offer a widespread consensus as to the single best definition of technology, there seems to be some convergence on certain important points concerning this concept. First, there seems to be some agreement that technology concerns either the mechanical or intellectual process by which an organization transforms resources into final goods or services. In other words, technology refers to the transformation process whereby mechanical and intellectual efforts are used to change inputs into outputs. Second, the diversity of opinions on a definition of technology may relate to the level of analysis at which the concept is viewed.

Perrow (1967) defined technology as an individual's direct actions on some raw material in an attempt to change it and organizational structure as the form of an individual's interaction with co-workers. He related technological routinization to the early recognition of problems and to the extent of standardization of search processes when problems occur. He argued that in order to operate effectively any type of technology has certain organizational requirements which will be reflected in the pattern of sequences used in performing the tasks and the characteristics of the knowledge used in the work flow.

Woodward (1965) suggested that technology, more often than size, is related to variations in organizational structure. She, for example, showed that regardless of the size of firm there is a consistent tendency for managers and supervisors to supervise fewer workers as technological complexity increases. These assertions quickly met challenges from proponents of size as the more important determinant of organizational structure. The Aston group showed that organizational size, rather than technology appears to exert the more significant influence on structure. March (1981) also dealt with the controversy over the relative importance of size and technology. It was found in a study of 50 Japanese factories that structural differentiation and formalization are clearly more a function of size than of technology. However, supporting many earlier views on the effects of technology, the results show technology to have a more significant and stronger impact than size on the span of control. It was also found that some of the components of structure vary independently both of size and technology.

The Aston group's findings demonstrated that technology, measured by the degree of integration between tasks, was not shown to influence structure. However this view was challenged by Aldrich (1972) and Child and Mansfield (1972) who asserted that structure is shaped by the technology used.

Thompson (1967) suggested a basic relationship between technology and organization in the proposition that organizations rationally link technology and organization structure to minimize coordination costs. This concept explains the interdependence among work units and the way tasks are coupled together. The construction industry is a classic illustration of how organization and technology are linked. The subcontracting and specialist trade system depends upon different groups using different aspects of technology.

The theory suggests that coordination and production costs are minimized by the use of specialization of the labour and the technology which is used. There are three ways in which tasks can be coupled together. First is pooled coupling, where members share common resources but are otherwise independent. For example, two specialist trades sharing cranage or another major item of plant. Second is sequential coupling, where the output of one member becomes the input of another member, e.g. a steelbender bends bars which are then fixed by himself or others into a form provided by the carpenter. Other examples would be a bricklayer building a wall and the wall is his output; the wall then is the surface that the plasterer uses as an input resource.

Prior to concrete being poured the trades must merge their activities. Finally, in reciprocal coupling members feed their work back and forth among themselves; in effect each unit or member receives inputs from and provides outputs to the others. An example here would be heating and ventilating and electrical control trades. Pooled coupling involves the least amount of interdependence and reciprocal coupling involves the most amount of interdependence among activities.

Galbraith (1973) argued that where the tasks undertaken by an organization are characterized by uncertainty (this may be expressed as uncertainty about the resources needed or technical complexity) then the information processing necessary to accomplish the task is increased. Galbraith (1973) noted that the quantity of information to be processed shapes organizational design.

For example, when construction managers are faced with projects which are characterized by uncertainty then organizational design creates self-contained tasks and the organization needs to ensure lateral relations between the tasks. These two distinct strategies are used in management-based procurement methods to deal with the uncertainties brought about by fast track construction. These strategies fulfil the systems theory proposition concerning separation of the management and production systems (Walker, 1989; Rowlinson and Walker, 1995).

The environment

The environment is not looked at as an independent entity, but as a collection of conditions with specific impacts on the organization. In addition, the environment is not taken as a single entity, since every organization faces multiple environments which can be characterized by three dimensions. What is being investigated here is the 'immediate' environment of the project.

First, an organization's environment can range from stable to dynamic. A variety of factors can make an environment change along this dimension and real problems are caused by changes that occur unexpectedly for which no patterns could have been discerned in advance. The factors that have been identified to influence the stability of the environment include unpredictable shifts in the economy, variations and changes in the client's requirements, changes in project goals and labour shortages.

Second, an organization's environment can range from simple to complex depending on the comprehensibility of the work to be done, and focuses on whether the factors in the environment considered for decision making are few in number and similar or many in number and different. The dimension of complexity can be measured by the number of subcontractors (whose work has to be coordinated) and by type of activity, the scale of involvement of the client and its representatives and the input required in programming and controlling the work.

Third, an organization's environment can range from friendly to hostile. The dimension of hostility affects structure through the predictability of the work and more importantly the speed of response, since very hostile environments generally demand fast reactions by the organization. Hostility is influenced by competition, by adverse relations between involved parties including industrial relations, by project location and by extreme weather conditions. Each of these environmental dimensions will influence the design of the project organization's structure.

In a stable environment, an organization can predict its future conditions and thus standardize its procedures from top to bottom, establish rules, formalize work and plan actions. The structure becomes more rigid and the chain of command and responsibility more clear. In a dynamic environment the structure is driven towards an organic state, since the organization cannot easily predict its future activities and cannot rely on standardization or formalization as a coordinating mechanism but must seek mutual adjustment and encourage informal communication.

In a simple environment, information can easily be consolidated and understood which enables the organization to centralize control and coordinate at the top of the hierarchy with little reliance on liaison devices and mutual adjustment for coordination. When the organization is faced with a complex environment it encounters problems of comprehensibility and consequently decisions are decentralized to prevent the effects of overloading. Authority to take decisions is delegated to middle line managers, staff specialists and trained professionals at the operating core. The units or subunits possess the ability to take decisions for themselves on issues which are reserved for a higher level in a comparable organization.

The hostility dimension has a special effect on structure through the intermediate variables of predictability of the work and speed of response for fast reactions by the organization. Hostility demands an immedite but temporary centralization of structure and direct supervision for the tightest means of coordination and control. When an environment is not uniformly hostile across its range the organization is encouraged to differentiate its structure and use selective centralization both in the vertical and horizontal dimensions.

The dimensions of stability and complexity each describe a specific structural characteristic that emerges from uniformly treated environmental conditions. However, the above dimensions are more powerful when they interact together to generate specific types of structures and in particular when they are presented in a matrix form. In addition, the dimension of hostility is viewed as imposing a special condition on the two-dimensional matrix. Extreme hostility drives an organization to centralize its structure temporarily, irrelevant of the initial conditions.

Technology

The technology variable was also articulated into three dimensions, namely

certain $\longleftrightarrow$ uncertain
simple $\longleftrightarrow$ complex
interdependence

The dimension of uncertainty is measured by the intermediate variables of predictability of work activities and variability of work items reflecting the prior knowledge of the organization concerning the work. As the technological certainty increases, the technical system becomes more regulating and, consequently, the work activities become more routine and predictable, lending themselves to standardization of skills and processes. Control is more formalized and impersonal and the structure more bureaucratic. Due to predictability of the system, staff in the organization can produce detailed plans early in the life of the project and design work flows and, thus, become more involved in the supervision and so decentralize authority. In a non-regulating system control of the operating work remains with the skilled operatives and their direct supervisors producing an organic structure.

The dimension of complexity, reflecting the sophistication of the technical system, is measured through the ease with which the work of the organization can be understood, the use of unfamiliar design standards or construction methods and the number of simultaneous work activities. These variables increase the reliance of the organization on functional specialization for decision making and, consequently, promote decentralization selectively to where the technical experts are found.

Furthermore, this reliance will affect the proportioning of administrative intensity, because allocation of responsibilities to professionals in technical fields alters the amount of coordination and results in a higher administrative ratio for the construction team. In a complex organization, one can expect to see multiple differentiation, that is the greater the number of subcontractors, the greater the complexity of the organization. The project organization requires an elaborate administrative structure and liaison devices to make decisions.

Interdependence in an organization exists at many levels and it is an indicator of the extent to which work processes are interrelated such that changes in one affect the state of others. There may be two broad levels of interdependence between tasks and between organizational functions. Interdependence may be of three types.

1. Pooled – common services serve all the players.
2. Sequential – a sequence of operations performed by the players.
3. Reciprocal – when the work moves backward and forward between the players.

Crichton (1966) pointed out that the building process is characterized at its formal level by a preference for sequential interdependence. Reciprocal interdependence is extensive between parties within the design and the construction subsystems depending upon the degree of overlap and the nature of the interface. The above interdependences affect the type of coordination in such a way that one may expect coordination by standardization for pooled interdependence, by plan and establishment of schedules for sequential interdependence and by mutual adjustment for reciprocal interdependence.

Due to the lack of spatial distance and close physical proximity and the need to couple their activities, the organizational members are frequently engaged in informal communication which in turn encourages coordination by mutual adjustment. In fact, it may be hypothesised that on a building project, in particular where there is reciprocal interdependence in a multigroup situation, there will be mutual adjustment by committees or liaison groups.

The involvement of different trade specialists in a project will require a greater amount of horizontal decentralization for the purpose of smoothing the path for coordination by mutual adjustment and vertical decentralization so that the activities of each unit are supervised by one manager probably from the same trade.

The dimension of interdependence manifests itself by the degree of physical congestion, the degree of mechanization, the degree to which resources are shared and by the distinguishable successional number of phases in the construction process.

Table 2 Characteristics of various environments

Dimensions of the environment	Prime structural characteristics
Stable	Insulate and standardize the activities of the operating core, establish rules and written manuals to formalize behaviour, greater use of action planning and achieve as precise an ordering of functions as possible to bring about regularity and predictability
Dynamic	To coordinate different parts of the organization the need for continuing communication is correspondingly increased, reduction in the use of rigid procedures and job specifications resulting in less bureaucratic control and reliance on more flexible and less formalized coordination mechanisms
Complex	Decentralization of technical and administrative decisions in particular among the professionals of the operating core and the use of mutual adjustment as a coordinating device.
Simple	The coordination is achieved by centralization since there is no problem of comprehensibility to require the delegation of administrative or operating decisions among various units
Hostile	An immediate but temporary centralization of structure and greater reliance on direct supervision for tightest means of control
Friendly	There is no requirement for temporary or selective centralization in vertical or horizontal dimensions to protect the organization from external influences.

Methodology

Having identified two key variables influencing project organization – design environment and technology – it is necessary to identify ways in which these variables can be assessed. Each key variable was broken down into a number of dimensions which when combined together would describe the environment of a project and the technology used. The dimensions used for each key variable were as follows.

Environment	Technology
Stability	Certainty
Complexity	Complexity
Hostility	Interdependence

The dimensions of environment are described in Table 2 and those of technology in Table 3.

The choice of research method merits justification. The research uses convergent methodology – a combination of methodologies which study the same phenomena. The issue of structure is triangulated by making three separate assessments. First, observations of the project organization were made, second, visits were made to the site itself and, third, discussions with the project manager addressed issues raised by the former two. Conclusions are drawn through a comparative method, that is looking at the same process in different settings.

In short, the approach uses qualitative methodologies. It does not seek rigid adherence to the positivist and quantitative methods but uses methods familiar in the most social of the social sciences, sociology and anthropology, which have looked for experiences and patterns rather than solely quantification. Consequently, the research methods draw upon the experiences of the researcher as a skilful construction observer of the organization structure used and sees the project manager as a participant in the project organization structure. This enables judgements to be made for purposes of the research. For a discussion of the issue of research paradigms in the construction industry see Green (1994)

Table 3 Characteristics of various aspects of technology

Dimensions of the technology	Prime structural characteristics
Certain	Work in the operating core is broken down into routine and standardized tasks which can be executed by unskilled workers and standardization drives the structure towards a bureaucratic structure since control is more formalized and impersonal
Uncertain	The middle level of the organization closest to the operating core is less structured and encounters less repetitive tasks and the work in the operating core has less procedural specifications and is too fluid to be formalized
Complex	A greater use of engineers and technical support staff promoting horizontal decentralization and greater use of liaison devices at middle levels and more reliance on task forces and standing committees as substitutes for more rigid methods of coordination
Simple	At middle levels the reliance on liaison devices is very little, there is less participation by the technostructure in making technical decisions and the administrative ratio is very small
High interdependence	An increase in the capacity to handle communication by devising informal methods and avoiding the lines of command, facing complicated situations the organization selects the most adaptable coordinating mechanism of mutual adjustment and the organization can also divert to scheduling information and feedback to standardize the outputs

(and for a general discussion see Easterby-Smith *et al.* (1991)).

The data were collected with the individual project being the unit of analysis and information was compiled by interviewing the project manager and inspecting project documents such as drawings, programmes and site minutes. The organizational structure was also depicted for each project. The *aide-mémoire* used in the data collection is presented as Appendix 1. The collection of data was done in a semi-non-directive manner and participants were not required to give a response to questions that they may have never considered or on which they had no clear opinion. The methodology adopted does not allow for a rigorous statistical analysis of the results. A simple majority of cases agreeing with the hypotheses was taken as the criterion for acceptance but, for those hypotheses accepted, at least 80% of the case studies conformed with the hypothesis.

There were inevitably interjections during the interviews which aimed to enrich the data collected by using specific examples to illustrate general statements. To reduce the ambiguity and to acquaint the participants fully with the nature of the research, the objectives and rationale behind the approach were addressed in initial discussions. Such details helped to minimize the fear and anxiety of participants in the research. The anonymity of the respondents was stressed.

The hypotheses

The key variables reported led to the formation of several hypotheses.

Environmental

E_1: the more stable the environment the more bureaucratic the structure.

E_2: the more complex the environment the more decentralized the structure.

E_3: the more hostile the environment the greater centralization of structure.

Technological

T_1: the more certain the technical system the more bureaucratic the structure.

T_2: the more complex the technical system the more decentralized the structure.

T_3: the more interdependent the range of activities, the more decentralized the structure and greater functional specialization.

The sample

The sample for the research comprised of 18 construction projects in the UK. This sample was selected from a range of contracts submitted by 18 building and civil engineering contractors. As far as possible the cases were drawn from different regions of the UK and different types of project. Heterogeneity was important and so the sample contained building and civil engineering projects, privately and publicly funded work and commercial, industrial and residential projects.

Inevitably there are difficulties in obtaining a microcosmic sample when the researcher is invited into an environment. Although the sample cannot be classed as representative of the industry as a whole it is a diverse sample. Brief details of the projects used as case studies are given in Appendix 2. Each case study was analysed as a single entity against the hypotheses.

The results

The results of the case studies are presented in Tables 4 and 5.

Dimensions of environmental – case study findings

The case studies examined the nature of the project environment. To restate, the environment was classified as being stable or dynamic, simple or complex and friendly or hostile.

The research participants were asked to dichotomously describe the project environment. For example, a project manager being interviewed had to describe the environment as either 'stable' or 'dynamic'. The coding was undertaken by the researcher following the interview with the research respondent.

The responses, which are summarized and presented in Table 4, are based on the contract managers' interpretation of real situations encountered from the commencement of the projects up to the time of interview. This approach required a judgemental decision and a commitment to understanding the organizational phenomena from the respondent's own perspective.

The judgements made for each combination were translated into combinations or 1 or 0 (Table 4). The coding of each variable was based upon two sets of evidence. The first test draws upon the discussion elicited from the *aide-mémoire*. Secondly, the descriptions of the dimensions of the environment were shown to the respondents and they were invited to choose a description of their project environment. Thus, an environment is selected which is said to hold for the project and is corroborated by interview.

It is recognized that the environment of projects is unlikely in practice to be totally stable for totally dynamic and that the balance between these states will change over time but in order to codify the data this bifurcation was adopted.

As can be seen in Table 4, the 'stable' dimension has been identified in 10 of the cases and where this occurred the project standardized the activities of their operating cores and established rules and written manuals to formalize behaviour. The *aide-mémoire* (questions 17 and 19) was used to inspect the relationship between projects which experienced stable environments and standardization of work behaviour.

The discussions also reveal an overwhelming support for describing the environment as complex and thus the tendency towards decentralization of technical and administrative decisions and the use of mutual adjustment as a coordinating device. On the hostile–friendly continuum the emphasis is on the hostility of the environment and the case studies reveal that this resulted in temporary centralization of structure and greater reliance on direct supervision. These structural effects were determined from the interviews with the 18 project managers.

Dimensions of technology – case study findings

The three dimensions of technology were assumed to act across all levels of site organizations. In order to determine which aspect of the technical system imposed the greatest influence, case studies were used to review the project situation and the technological aspects of the project were discussed with the project managers in the interviews.

The results are presented in Table 5 as combinations of 1s and 0s, indicating that in the majority of cases the technical aspects of site operations were considered to be certain and complex in nature and highly interdependent. The interviews reveal that most organizations experienced predictable tasks and little variability in their

Table 4 Case study results: environment case studies

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Stable	1	1	1	0	0	1	1	0	0	1	0	0	0	1	1	0	1	1	10
Dynamic	0	0	0	1	1	0	0	1	1	0	1	1	1	0	0	1	0	0	8
Simple	0	0	0	0	0	1	1	1	1	0	0	1	0	1	0	0	0	0	6
Complex	1	1	1	1	1	0	0	0	0	1	1	0	1	0	1	1	1	1	12
Friendly	1	1	0	0	0	1	1	0	1	0	0	1	1	0	0	0	0	1	8
Hostile	0	0	1	1	1	0	0	1	0	1	1	0	0	1	1	1	1	0	10

1 indicates total compliance with the corresponding dimension and 0 indicates non-compliance with the corresponding dimension.

Table 5 Case study results: technology case studies

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Certain	1	0	1	0	0	1	1	1	1	0	1	1	1	1	1	0	1	0	12
Uncertain	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	1	6
Simple	0	1	1	0	1	1	1	1	1	0	0	1	0	0	0	0	0	0	8
Complex	1	0	0	1	0	0	0	0	0	1	1	0	1	1	1	1	1	1	10
High interdependency									Highly interdependent										18

1 indicates total compliance with the corresponding dimension and 0 indicates non-compliance with the corresponding dimension.

operations. This introduces a strong element of certainty concerning the technological aspects of the work and encourages the organizations to move towards a bureaucratic structure with standardized tasks and regulated behaviour.

The results also indicate that the performance of the tasks required relatively sophisticated technical systems and the use of unfamiliar design standards and construction methods. In order to deal appropriately with technically complex systems, the organizations tolerated structural differentiation and an elaborate administrative structure including the use of engineering and technical support staff. There was a greater reliance on standing committees and task forces as means of coordination in the majority of the case studies exhibiting technical complexity (cases 1, 4, 10, 14, and 16–18).

A high degree of interdependence among work activities existed in all the projects and appeared as a dominant aspect of technology and processes in construction works. Organizations selected the most adaptable coordinating mechanism of mutual adjustment and diverted to scheduling information and feedback to standardize the outputs. The majority of the organizations in the case studies adopted such mechanisms.

These findings were matched with the characteristics of organizational structures as observed from the case studies. The linkage of structure with technology was achieved by using the prime structural characteristics described in Tables 2 and 3.

The structure of the case study projects was gauged from interviews with the project manager and observations of organization charts, etc. This was matched with the interview data. These findings were then compared with the prime structural characteristics as defined in Tables 1 and 2. From the environmental, technological and organizational data it was possible to accept or reject certain hypotheses based on the outcome of the individual case studies. The hypotheses were tested by constructing a series of propositions which were presented to the research respondents.

The propositions related to the hypotheses and respondents were asked to score on a scale of 1–10 the accuracy of the proposition as it related to their project and their ability to judge the issue in question – again on a scale of 1–10.

The products of these scores were taken as an indication of the acceptability of the hypotheses. A threshold of 50% was used as a cut-off point for acceptance/rejection. These are presented in Table 6.

Findings and discussion

The basic components of organizational parameters of projects were discussed earlier. It is evident that these

Table 6 Summary of findings

Rejected	Accepted	Structural characteristics
E_1		Stable conditions of environment do not produce a bureaucratic structure and highly formalized behaviour. Instead there is a reliance on more flexible coordination mechanisms and less rigid work procedures
	E_2	Decentralization of authority mainly along the vertical dimension
E_3		Hostile conditions do not cause a centralized system. However, organizations have a tendency to redraw their boundaries and create buffer agents to protect the organization from external influences
T_1		Certainty in technical systems does not lead to breaking down of the tasks into routine and standardized work processes resulting in a more bureaucratic system
	T_2	Greater flow of informal communication and use of liaison devices and decentralization along the horizontal dimension
	T_3	Avoiding the formal lines of command and adopting a flexible coordination mechanism

parameters when related to a technical and environmental framework can take various forms and their interrelationships can empirically demonstrate the existence of a link between the technology, environment and organizational structuring.

The main characteristics of organizations were found to be the coordination of specialized and differentiated tasks, often most clearly visible at the site level. The participation of a variety of trades in the production of the work and extensive reliance on the practice of external resources (plant labour and materials) required managers to have a wide knowledge of different trades and materials to coordinate work rather than to rely solely on the standardization of skills and the routinization of the construction processes.

To control the work and integrate the diverse tasks, direct supervision by line managers appeared to be the most common and acknowledged method of coordination. Due to a relatively small number of specialists employed at the building sites, the line supervisors had to be technically competent in a number of different trades. Their technical competence was, in most cases, the kind acquired by long practical experience rather than by professional training.

A high level of interdependence among tasks produced a greater need for direct contact between the line supervisors and the operatives so that the activities could be closely monitored. As a result, the labour force was broken down into small primary working groups with small spans of control creating a more intimate and informal relationship between the group and their immediate superiors[1]. For more complex tasks with a high degree of interaction between different trades or for unstructured and unspecified subtasks, mutual adjustment between work groups and individuals was common and frequent contacts outside the chain of authority were commonly relied upon for work flow coordination[2].

Although direct supervision provided by a small managerial hierarchy was considered as the primary means by which the non-routine and routine activities were structured as an integral system, organizations could not adequately cope with all the work flow interdependencies and therefore allowed personal liaisons across trade contractors' boundaries and discretion in the work of skilled craftsmen to achieve the desired standardization and quality of outputs. This points to the rejection of hypothesis E_1.

These phenomena basically reflect a systems view of project management where the managing and operating systems are differentiated (Walker, 1989). By concentrating on the managing system the project managers can facilitate the use of the various coordinative devices whilst allowing freedom to the participants to get on with the tasks at hand. Thus, the principles of decentralization are reinforced in a complex and hostile environment. Hypothesis E_2 receives support but E_3 does not.

Regular assessment of project performance was considered as a more suitable means of control and evaluation of project progress. In some cases where the internal structures of organizations were broken down into a series of functional units, distinct organizational goals could not easily be identified and, hence, action planning emerged as an option to regulate outputs and specify the activities requiring tighter control. However, the extensive use of action planning and imposition of specific decisions were often avoided since they were thought to impede the flexibility of organizations to respond creatively to the environmental uncertainties.

The site organizations of civil engineering projects were characterized by a clear division of tasks that corresponded to the disciplinary specialization of supervisory and engineering personnel leading to a functional structure. The functional structure was more appropriate for operations where the project plan called for distinct functional phases, since such arrangements reduced the requirement for interdisciplinary coordination.

The organizations of large building projects adopted a more flexible matrix structure that enabled the integration of numerous interfaces between many sub- or trade contractors while retaining a good deal of decision making at the centre. The smaller organizations were characterized by centralization of power for formulation of strategy and minimal formalization to allow rapid response. The structure had to ensure that strategic responses reflected full knowledge of 'what had to be done' and thus it was necesssary for the line supervisors to be familiar with both the technical aspects of the projects and the operating systems.

To reduce the need for continuous communication between performers of repetitive activities and to bring about a greater tolerance for interdependence, a limited amount of formalization and standard operating procedures were covered by manuals issued to all sub- or trade contractors. These manuals covered three main areas of site operation: planning and information control, subcontract management and health and safety procedures. Learning by rote, training and work experience of staff appeared as primary means of standardization and, in conjunction, written policy manuals and performance guides were considered as reinforcing factors in familiarizing the employees with expected behaviour and performance on site.

The organizations did not reflect an arbitrary desire for great order and the nature of the tasks and their variability made precise and carefully predetermined coordination inappropriate. A need for a variety of

[1] A sterotyped description of a small labour-only subcontract gang.
[2] A condition easily recognized as being descriptive of specialist contract.

coordination mechanisms to create an equal balance across the entire structure of organizations was clearly evident. The formal and informal methods were often intertwined and sometimes indistinguishable, conveying the important message that formal structures reflected official recognition of naturally occurring behaviour patterns.

However, the behavioural specifications of jobs and standardization of procedures or extreme formalization of behaviour through written rules were not favoured as either sufficient or as primary forms of standardizing the work processes. Instead, mutual adjustment and less formal methods of communication such as regular site meetings emerged as significant factors in helping the organizations to cope with the variability of activities and their required standardization.

The overall effect of a stable environment where organizations can predict their future conditions and a regulating technical system where the operations are routine and predictable impose similar demands and produce a bureaucratic structure with more formalized and impersonal means of control. However, the above findings do not support hypotheses E_1 and T_1 and their underlying assumptions concerning the relationship between structure and the two environmental and technological dimensions of stability and certainty are rejected. On the other hand, hypotheses T_2 and T_3 are supported.

The contract managers were given total responsibility over the control of operations, the execution of the contracts and the supervision of the project team and since diversity of conditions and particular site characteristics meant that many decisions had to be taken immediately without reference to the head office, they often took residence on sites.

In setting up the organizations, the aim of the contract managers was not to establish relationships between structural variables but to find the most effective arrangement for efficiency and control. Organizations were temporary project-based units which drew their project teams from either the functional department at the head office or from specialized contractors. Discussions revealed that formal authority usually rested in the line structure and there was little transfer of power to the non-managers and support specialists.

However, some structures experienced horizontal decentralization when informal power was delegated to the support specialists to the extent that they had the expertise to make technical decisions. Although the line managers with formal authority and support staff with technical knowledge joined together in regular meetings, the distinction between them remained clear.

Due to the complexity of construction operations and the interdependence of activities, in particular among trade specialists, vertical decentralization was a very widespread organizational phenomenon and a natural delegation of power occurred allowing those with job responsibilities to perform their tasks more efficiently. Therefore, vertical decentralization of the operating core became a permanent feature of the decision-making system, though line managers remained responsible for the supervision of respective subcontractors and the coordinative decisions. In addition to supporting hypotheses E_2 and T_2, the results are indicative of the fact that participation in decision making retained a positive association with the environmental and technological complexity.

The distinctions between the two dimensions are made clear by their definitions, but the hypotheses are suggestive of similar structural impacts amounting to horizontal but mostly vertical decentralization. The influence of the technical system was not solely restricted to the design of structures in the operating core since, as exhibited in the organization charts, a more elaborate support structure consisting of staff specialists was a common feature of many organizations with complex tasks.

Conclusions

The organizations were found to be open systems dependent on exchanges with their environments and often in a problematic way dominated by constraints and influenced by unfavourable conditions. Hypothesis E_3 was based on the theoretical premise that observed hostility in the environment decreases the dependence of organizations on decisions reached through joint processes. The research found no evidence to support the assertion that organizations respond to turbulent and threatening environments by redefining the authority for action and restructuring into a more centralized form as long as the hostile conditions persist.

The effects of external conflicts and disputes encouraged the contract managers to redraw the organizational boundaries and act as buffer agents to protect the balance of responsibility and authority of each of the individual members of project teams from unnecessary interventions and outside pressures.

The research indicates substantial variations and a lack of complete conformity between the theoretically extracted hypotheses and the actual structural characteristics of the organizations which were operating under the specified environmental and technological conditions.

These non-conformities can be explained when characteristics of the project team are identified: a temporary team composed of independent organizations. Thus, the nature of the team is an additional contingency affecting the structure of the team. In essence, these two characteristics lead to a less bureaucratic and more decentralized structure than would be predicted using conventional organization theory. This is an issue which can be further addressed in future work.

Of particular interest is the way in which temporary multiorganizations appear to follow the prescriptions of systems theory in clearly differentiating between the managing and operating systems. The impact of such characteristics on the social system and their effect on project culture are also of significance and worthy of further study.

Limitations to the research

An additional issue which is rarely addressed in the organizational literature is the temporary nature of the construction team and the fact that the team is generally made up from members who work for different organizations. Cherns and Bryant (1984) described this as a temporary multiorganization.

These two characteristics, of temporariness and coalition formation between separate organizations, interact with the environment and technology variables to modify the organizational structure; they are an additional contingency. Thus, one might expect that the hypotheses derived above from a conventional view of organization structure may be modified when applied to the construction project team. Specifically, one might expect a less bureaucratic structure to develop as the team is both temporary and multiorganizational and that a more decentralized structure will exist even in a hostile environment as time and coalition politics work against centralization. Those hypotheses emerging from the study could usefully be the focus of subsequent research.

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Appendix 1: interview questions

The following questions were used to obtain information and to help the non-directive interview back to its original track in case of any deviations.

1. What were the major goals in structuring the site organization?
2. How did factors such as technology, size and project objectives influence the structure?
3. What portions of the structure changed and what portions remained constant when these factors changed?
4. Was it necessary to incorporate any unusual or unplanned elements in the structure?
5. Was it necessary to set up any groups to protect construction operations from external influences?
6. Did coordination requirements between the site members influence the formal patterns of communication?
7. Where there any bottle-necks in communication flow that altered the original set-up?
8. Did any alterations in project scope change the organizational structure?
9. What was the effect of various phases in the site operation on the structure?
10. Where there any changes in key personnel?
11. Did portions of the structure evolve to conditions different from those originally set?
12. Have you used the present organizational structure before? How is this similar or different from the last job?
13. What factors would you take into consideration in setting up the next project?
14. Did you have to accept any compromises in structuring the organization?
15. Did you experience any uncertainties in the formation of the structure?
16. Was it necessary to search for any alternative forms of organization?
17. How did normal company procedures influence the process of structuring?
18. Was it possible to use past projects or company standards as starting points in structuring?
19. Were there specific experiences on past projects which indicated that one structure performed better than others?
20. Did any departments handle difficult tasks that were recognized by the organization?
21. Did any parts of the organization contradict the basic project goals?
22. What types of problems took the longest time to solve?
23. What are your personal theories regarding the structuring of organizations?

Appendix 2: case study summary

Case number	Type	Cost (£)	Construction duration (months)
1.	Speculative office development medium rise, tour centre	23.5 M	33
2.	Refurbishment of two-storey office	2.3 M	6
3.	Distribution depot and warehouse	3.1 M	8
4.	New country hall	24.0 M	33
5.	Refurbish and rebuild medium rise, city centre office building	1.30 M	18
6.	Tour centre bypass road 3 km in length	5.30 M	11
7.	Extension and alteration of superstore	1.7 M	8
8.	New prison	7.0 M	30
9.	New prison, 11 storey	21.0 M	30
10.	Seven-storey office block in city	5.5 M	22
11.	Refurbishment of city centre, listed residential building	2.0 M	18
12.	Shopping precinct in development zone	24.0 M	20
13.	Coastal relief road, dual two lane, 43 km	12.1 M	30
14.	Additional passenger facility at international airport	7.2 M	16
15.	Strengthening and maintenance of bridge	30.0 M	24
16.	New, city centre national archive	270.0 M	72
17.	First two phases of city centre development of 14 major office blocks plus civic space plus retail space	150.0 M	12
18.	Plant installation to pharmaceutical factory	15.0 M	24