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Determinants of performance in the traditional building process

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Even though an estimated 80 % of all building projects are procured by some form of the traditional building process, the project to project variations in performance are still subjectively and individually explained. The present paper addresses this particular domain. Using interorganizational conflict among the project's task-organizations as a yardstick, the impact of a number of conflict-inducing organizational variables upon project cost, time and quality is measured and significant determinants of performance at these three levels are identified.

Keywords: Building procurement, building process, project performance, regression analysis.

Introduction

As the main product of the building industry is normally purchased before it is designed or built, the usual methods of evaluating and selecting 'off the shelf' products cannot be applied. Instead, the building client is expected to initiate and organize a project procurement process that will ultimately deliver the desired building. To do this successfully, however, the building client has to deal with an industry that is frequently described as a 'multi-industry', referring to its characteristic that for each project a large number of independent specialist organizations – ranging from professionals to businesses – have to be brought together within the framework of a temporary project organization.

The process of assembling the project organization is akin to that of organizational design in other industrial situations. Here, as elsewhere, the central problem remains the same: how to set up an organizational and management system that will allow for the highest overall project performance to be achieved? However, to attain this, the building client needs answers to questions such as: 'does this form of organization allow the basic operations of the process to be realized more effectively than any other?' or 'which aspects of the organization are critical for achieving the desired end product?' Or again 'what level of performance may be expected from a particular organizational or managerial intervention?'

As yet, very little concrete information is available to a building client that could be of assistance in designing the project organization. Traditionally the building industry has opted for a generic approach to organizational design. That is, a limited number of generic prototype organizational arrangements are identified, their advantages and disadvantages based upon prior experience are listed, and the prospective building clients are encouraged to match their requirements and constraints with these models as closely as possible (Haviland, 1976; AIA, 1981; NEDO, 1985). However, a serious difficulty with this approach has been

0144–6193

pointed out (Haviland, 1981) as only a limited number of generic organizational forms can be identified, they suffer from problems of aggregation (combining dissimilar items) and over simplification (leaving out items that do not fit). Furthermore, generic models allow only a partial evaluation and offer very little scope for identifying those particular aspects of the organization which may be dysfunctional (requiring removal) or critical (requiring monitoring). Ideally, therefore, systematic and exhaustive investigation of the main determinants of the project organization is necessary.

Only recently have some systematic investigations into the determinants of project organization started to emerge. For instance, recent articles report the influence that different contractual arrangements have on risks, flexibility and costs in building projects (Nahapiet and Nahapiet, 1985), of the impact of fast-track methods of construction on the design of buildings (Fazio *et al.*, 1988), and of evaluating different procurement strategies by taking into account factors such as speed, certainty, flexibility, quality, etc. (Skitmore and Marsden, 1988). The present study also fits in this category as it attempts to measure the impact of some organizational variables upon the performance of the project. The scope of this study, however, is constrained by two factors. Firstly, since most building projects are procured by means of the traditional building process (as defined below), the focus here is on this particular way of organizing the building process. Secondly, the main hypothesis underlying this study contends that an improperly organized and managed building process induces interorganizational conflicts among the participating task-organizations and that such conflicts inversely affect the project's performance (Mohsini, 1984; Mohsini and Davidson, 1986; Pretorius and Taylor, 1986; Davidson and Mohsini, 1987; Davidson, 1989, Mohsini, 1989). Starting from this premise, the present study has identified a number of organizational factors which have been found to have caused interorganizational conflict in other industries, and measured their impact upon the traditional indicators of project performance in the building industry, namely, the cost, time and quality performances.

Traditional building process

The traditional building process is defined as 'the bases of design, organization and execution of building which have come to be recognized as normal practice over a considerable period in any country or region. It is characterized by the fact that all operations follow a set pattern known to all participants in the building operation, and by dependence on skilled craftsmanship for interpretation of instructions and execution of work' (UN, 1959). Most commonly, however, this term refers to the practice where, upon perceiving a need for a new facility, a building client approaches an architect/engineer to initiate a process to design, procure and construct a building to meet his/her specific needs. The process, in turn, almost invariably consists of the project being designed and built by two separate groups: the design group and the construction group.

The design group, typically, is coordinated by an architect/engineer. Depending upon the circumstances of the project at hand, it may also include other design professionals and specialists such as engineers, estimators, quantity surveyors and so on. The principal function of this group is to prepare the designs and specifications of the work and other technical and contractual documents. The construction group, on the other hand, is usually coordinated by the general contractor and consists of a host of subcontractors and suppliers/manufacturers of building materials, components, hardware and subsystems. This group is primarily responsible for the construction of the building project.

Characteristics of the traditional building process

The organization of the traditional building process is greatly affected by the competitive tendering system and the sequential arrangement of work. Under the competitive tendering system, contractors are invited to bid for the project on the basis of documents such as scale drawings, bills of quantities, general and particular specifications, and so on. Generally the contractor who can undertake to execute the work for the lowest price is selected.

The sequential arrangement of works, on the other hand, leads to the general build-up of the project organization. From the time the building client makes the initial contact with the architect/engineer to the completion of the project, a large number of task-organizations become temporarily, though not simultaneously, part of the project organization, contributing to the materialization of the project. The temporary multi-organization thus created, however, is continuously confronted with disparities between two levels of organizational objectives: 1. The temporary objectives of the project and the organization that is set up to build it; and 2. The permanent objectives of the participating task organizations.

The first level of objectives in building projects is generally defined by the client system (i.e. the client in his/her socio-economic context). Various requirements and constraints are imposed upon the project jointly by the client and the environment within which he/she operates and within which he/she must build; the project organization is obligated to meet them. The second level of objectives includes those which are typical of all permanent organizations, namely, their survival in the market place, enhancement of their domains and their position in it, and so on. The architectural firms, the consulting engineers, the general and specialty contractors are all permanent organizations in their own right and as such have their own permanent organizational objectives.

Independent organizations, however, enter voluntarily into multi-organizational arrangements only under circumstances which they perceive as conducive to the enhancement of their organizational objectives. Accordingly, each interacting task organization has an issue-outcome interest on any given issue, that is to say, an interest in seeing that the issue is resolved in such a way that the outcome is most advantageous to its own organizational objectives. Where the issue-outcome interests converge, the interaction is likely to co-operatively ensure attainment of the mutually desired issue-outcome. On the other hand, where issue-outcome interests of the interacting task organizations diverge, their interaction generates contest processes to attain desired but mutually exclusive issue-outcomes (Tuite *et al.*, 1972).

The impact of the contest, however, must be put in perspective. In situations where single and independent organizations are competing for desired but exclusive issue-outcomes, such as in design competitions, the contest processes may actually be beneficial to the final outcome. On the other hand, on building projects where task-organizations have to work interdependently, the contest processes stemming from the diverging issue-outcome interests frequently lead to interorganizational conflicts and as a result have an adverse effect upon task performance.

From this point of view, for a project organization to function successfully it is necessary for each task-organization to be able to justify its issue-outcomes from its own independent organizational perspective. In other words, the pivotal point here is that the success of a multi-organization in achieving its first level objectives is dependent upon the extent to which factors that lead to interorganizational conflicts have been eliminated from its constitution, so that the participating organizations have the maximum likelihood of achieving their second level objectives.

Determinants of conflict in multi-organizations

What are the important organizational variables that can lead to interorganizational conflict and have a significant impact upon the project's performance? In the literature on organizational conflict, three categories of variables – domain consensus, availability and access to information and interdependence of tasks – have been found to have a bearing upon the attainment of objectives by task-organizations (Barth, 1963; Pondy, 1967; Schmidt *et al.*, 1972; Meyer, 1975). To test whether they also affect performances in building projects, the following theoretical/propositional framework was devised.

1. *Domain consensus:* Domain consensus is defined as the set of role expectations, both for the members of a task-organization and for the forces with which they interact about what the task-organization will or will not do. However, the role expectations are not established arbitrarily or unilaterally. Only when a task-organization's claim to a role is recognized by those who can provide it with the necessary support (such as the project organization), can a particular role concept be operational. But once the role boundaries (or domain boundaries) are established, they have a major effect in determining the organizational objectives set by the various task-organizations for themselves. In project organizations where the administrative boundaries violate the role boundaries of task-organizations, the objectives of these independent organizations are also threatened and consequently dysfunctional conflict is introduced.

In the building industry, for example, the various professions and trades have their roles (domains) fairly well defined and vigorously protected by their professional associations. Historically, these roles have evolved from conventions (defined as the commonly agreed rules, that enable the design, manufacture and construction of buildings to be better co-ordinated at all stages by which buildings were procured). Today, with many different ways to organize the building procurement process, many of these conventions do not hold and as a consequence the expected role boundaries do not always match the administrative boundaries within the building process. Whenever such a mismatch occurs, it leads to jurisdictional ambiguities which in turn induce inter-organizational conflict because in such situations it is difficult to assign credit or blame between two interacting task organizations. Thus it may be assumed that in project organizations where the scope of participation, i.e. the roles of different task-organizations, are clearly defined by management and clearly understood by the participants, there is very little chance of conflict arising due to jurisdictional ambiguities. It may also be reasoned that with the increasing degree of specialization – a process which is narrowing the domains of many traditional constituencies in the building industry – the role expectations can be more clearly delineated as well as more closely matched with the administrative boundaries of the building process. This, in turn, will reduce the chances of jurisdictional ambiguities and of dysfunctional conflict. In summary, then, the domain consensus category can be represented by two factors: a. The clarity of the scope of participation, and b. The degree of specialization.

Regarding the conflict arising from these two factors, it can be proposed that [$X1$] The greater the clarity of the scope of participation, the less the interorganizational conflict will be, and hence the higher the project team's performance, and [$X2$] The greater the degree of specialization of task-organizations, the less the degree of interorganizational conflict between them will be, and consequently, the higher the team's performance.

2. *Availability and access to information:* It has been noted that in multi-organizational situations any obstacle to interorganizational communications are conducive to conflicts because decision making which involves several independent organizations presumes an exchange of information and when this exchange is unsuccessful, co-operation between them can break down (Tuite *et al.*, 1971). Obstacles to exchange of information can be either because of unsuccessful transmission of information, or due to systematic blocking of information by one party in order to prejudice the other party in the achievement of its goals.

Unsuccessful exchange of information is generally caused by systematic misunderstandings, insufficiency of information or noise. The inter-organizational conflicts arising due to the unsuccessful exchange of information, however, should be regarded as pseudo conflicts because these situations in themselves need not give rise to any conflict if the parties manage to exchange information more efficiently.

Blocking of information, on the other hand, can give rise to very dysfunctional conflicts. Since information is a vital resource, especially in interdependent and sequential performance of tasks as on building projects, where one organization's task performance may entirely depend upon the information about the preceding task, its availability can have a determining effect upon the performance of the participants in the project. The blocking may be intentional or unintentional. For example, manufacturers of windows may withhold test data about the deterioration of the air tightness of their windows over several years of service; this is an intentional denial of information which can lead to expensive retrofit bills and result in conflict. On the other hand, a delay in relaying information by an architect may be quite unintentional but can also have detrimental effect upon the performance of other participants, also resulting in conflict.

Thus, information can be seen as a source of interorganizational conflict leading to negative effects upon the project's performance when it is unsuccessfully exchanged, unavailable or its procurement takes excessive time. It may therefore be proposed that [$X3$] The greater the sufficiency of information, the less the chance of interorganization conflict will be, and hence the higher the level of the team's performance, and [$X4$] The greater the time needed to acquire the necessary information, the greater the chance of conflict will be, and hence the lower the level of the team's performance.

3. *Interdependence of tasks:* This refers to the extent to which two independent organizations depend upon each other for assistance, information, compliance or other co-ordinative acts in the performance of their respective tasks. Interdependence can be symmetrical or asymmetrical (i.e. both or only one of the two concerned organizations has an incentive to co-ordinate), and it can range from high to low. It has been associated with high probability of conflict and is also seen as the root cause of lower project performance and even organizational breakdowns in the building industry (Crichton, 1967).

If the task performance of a unit depends on the task performance of other units and is accepted as such, then it is expected that the system is most likely to perform without any external controls. However, studies indicate that task interdependence, while it provides an incentive for collaboration, also represents an occasion for conflict and provides the means for bargaining over interorganizational issues. In particular, symmetrical interdependence between organizations may promote collaboration but asymmetrical interdependence leads to conflict. For example, a structural engineering firm may resent the asymmetries in their relationship with the architectural firm on a project if the process is such that they are expected to understand the eccentricities of the design, to get along with the architects, to produce a rational structural design without inducing significant changes in the architectural design and, at the same time, to accept that no reciprocals of these requirements are imposed upon the architectural firm.

The adverse effects of asymmetrical conditions are related to the fact that one of the two concerned organizations has little or no incentive to co-ordinate, though the more dependent organization may try to increase the incentive of the independent organization to co-operate by interfering with its task performance. The underlying assumption is that once the independent organization is made aware of the need for co-operation by the dependent organization, it will behave more co-operatively by supplying the needed assistance. This tactic may indeed achieve its purpose, and the conflict–interfering acts may cease; but frequently interference elicits a retaliatory response.

In summary, interdependence of tasks leads to interorganizational conflicts in those situations where the relationship between the interdependent parties is asymmetrical. And since sequential processes are inherently asymmetrical (First's output is the next's input), and asymmetrical interdependencies can lead to the breakdown of co-operation, it may be assumed that where greater task interdependence exists, there will also be a greater chance of interorganizational conflict. On the other hand, interdependence of tasks in a building process requires that effective co-ordination of these tasks is achieved. Accordingly, it may be assumed that greater co-ordination of tasks (and task-organizations) will reduce the chances of interorganizational conflicts. It may therefore be proposed that [$X5$] The greater the degree of interdependence of tasks due to the projects or organizational conditions, the greater the chance of interorganizational conflict will be, and hence the lower the level of the team's performance, and [$X6$] The greater the co-ordination of tasks, the less the level of interorganizational conflict will be, and hence the higher the level of the team's performance.

4. *Performance:* Although, the traditional measures of project performance – Cost, Time and Quality – are adopted here, no attempt is made to precisely define these measures. In fact, each task-organization is allowed to define and evaluate these from its own organizational perspective. Accordingly, organization A, for example, may encounter a particular project condition, say, a very high degree of task interdependence in the building process, but may evaluate its impact upon its cost performance as marginally negative, while on its time performance as highly dysfunctional. In the light of the propositional/theoretical framework developed earlier, this may be interpreted as suggesting that the proposed conflict measure, interdependence of tasks, has no negative effect on organization A's cost performance (i.e. A's cost related objectives were achieved as planned), while the time related performance was highly affected leading to adjustments in A's time related objectives.

Thus, the three traditional indicators of performance measured at the task-organizations' level, aggregated for all participating task-organizations, and used as the dependent variables in the present study, are identified as follows:

[$X7$] Refers to the project's performance in terms of Cost;
[$X8$] Refers to the project's performance in terms of Time;
[$X9$] Refers to the project's performance in terms of Quality.

Method

Four building projects in the Toronto Metropolitan Area were selected on the basis of being procured by the traditional building process, covering a wide spectrum of types, sizes and the level of technical complexity (Residential condominium, $22 million: Concert Hall, $39 million; Retail/Office complex $61 million; Hospital Expansion, $35 million), to provide data to test the above propositions. Within these, 21 task-organizations consisting of four categories – architects, consulting engineers, general and subcontractors, were asked to evaluate:

1. Project conditions reflecting the concerns in the above propositions,
   (Example: *X1* – Scope of Participation

Question: How clearly was the scope of your participation defined?
Answer: On a scale of 1 to 7, where: 1 = Extremely clearly, 7 = Extremely unclearly.)

2. The impact of these project conditions upon the cost, time and quality performance of their work.
   (Example: *X1* – Scope of Participation

Question: Please indicate to what extent the above ambiguity, if any, created uncertainties about: (a) Your cost estimates, (b) Your time estimates, (c) Your quality of work.
Answer: For each performance variable on a scale of 1 to 7, where 1 = To extreme extent, and 7 = not at all.)

The following model (Fig. 1) was used to measure interorganizational conflict and its impact upon the attainment of performance objectives.

The data thus collected is analysed in two steps. First, the multiple regression technique is used to regress the independent variables, *X1* to *X6*, upon each of the dependent variables – cost, time and quality. In principle, the multiple regression equation is constructed to assess the simultaneous effect of several independent variables upon the dependent variable. Usually, in the general multiple regression equation, the dependent variable is seen as a linear function of more than one independent variable. Such a general form is expressed as:

$$Y = a_0 + b_1X_1 + b_2X_2 + b_3X_3 + \cdots + b_kX_k + E$$

where Y represents the dependent variable and the Xs the independent variables. b_1 to b_k, designated as the partial regression coefficients, are the slopes of the regression line for each independent variable, controlling for the effects of the other. Thus, b_1, reflects the amount of change in Y associated with a given change in X_1, holding all other variables constant. a_0 designates the intercept point on the Y axis for all variables, and E designates the error component. The interpretation of the intercept, a_0, is fairly straightforward. It is the average value of Y when each independent variable equals zero. Thus, the value of the dependent variable will be equal to a_0 when the independent variables X_1 to X_k register zero. The interpretation of the slope, b_k = the average change in Y associated with a unit change in X_k, when the other variables are held constant, requires more attention. By this means of control, it is possible to separate out the effect of X_k itself and free it of any distorting influences by the

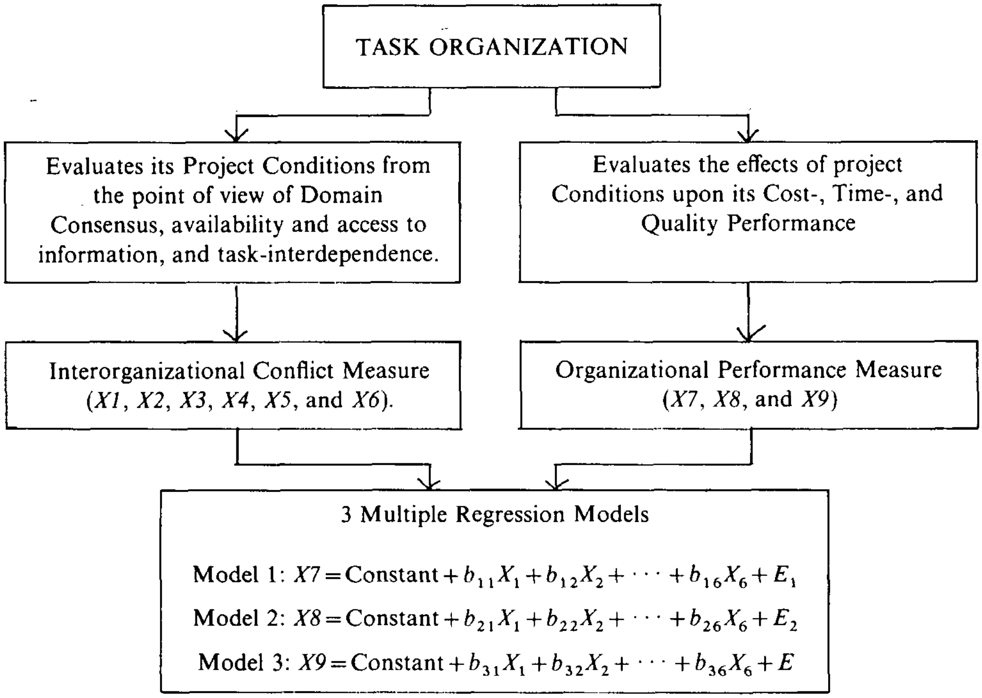

Fig. 1. Conflict/performance measurement model.

Where:
Conflict Measurement consists of: K1 = Domain consensus, *X1* = Clarity of the scope of participation, *X2* = Extent of specialization by task-organization; K2 = Availability and access to information, *X3* = Sufficiency of given information, *X4* = Time taken to procure further information; K3 = Task interdependence, *X5* = Tasks' dependence upon others, *X6* = Extent of co-ordination required; Performance Measurement consists of: *X7* = Cost performance, *X8* = Time performance, *X9* = Quality performance.

other independent variables. Such a slope is called a partial slope, or partial regression coefficient. Thus, according to the above regression, partial slope b_2 estimates that with a unit increase in the magnitude of the independent variable X_2, the average value of the dependent variable will increase by b_2 units.

Finally, to assess the goodness of fit of a multiple regression equation, the R^2 or the coefficient of multiple determination is employed. The R^2 for a multiple regression equation indicates the proportion of variation in Y 'explained' by all the independent variables. For example, $R^2 = 0.75$ indicates that all of the independent variables, X_1 to X_k, together account for 75% of the variance in the dependent variable. (See: Lewis-Beck, 1980, for a good introductory discussion to regression analysis.]

Obviously, it is desirable to have a high R^2, for it implies a more complete explanation of the phenomenon under study. Nevertheless, if a higher R^2 were the only goal, then one could do it by adding more variables to the equation. That is because an additional variable cannot lower the R^2 and it is virtually certain to increase it – at least somewhat. The inclusion of variables, however, should be guided by broader theoretical considerations as well as by a concern for the efficiency of the statistical analysis.

This brings us to the second step of the analysis, where, the three regressions are subjected to stepwise regression analysis to determine the most significant determinants for each of the performance variables. The SYSTAT statistical package was used for all statistical analyses.

Results and discussion

As the effects of organizational variables (*X1–X6*) upon the three performance variables are separately measured, the results and their discussion is also presented in three sections. Furthermore, since the focus of this paper rests upon identifying the most significant determinants of performance and evaluating their relative importance rather than their predictive powers, the results are also presented in the form of standardized partial slopes (*b*-weights).* These estimates indicate the average deviation change in *Y* associated with a standard deviation change in *X*, when the other independent variables are held constant. The B-weights thus allow the relative values of different variables, even when measured on different scales as in the present study, to be determined and compared. Finally, as the directions of the relationships between the independent and the dependent variables is indicated *a priori* in the propositions, only one-tailed significance of the regression variables need to be tabulated.‡

Determinants of cost-performance

The results of multiple and stepwise regression of the six independent variables upon cost-performance are presented in Table 1. The six variables accounted for over 81% of the variance in the project organization's cost performance. This is a very high proportion of the total variance and the probability of it occurring due to chance is less than 0.001. Nevertheless, it is important to note that only three variables, *X3* (sufficiency of given information), *X4* (time taken to procure further information), and *X5* (Task's dependence upon others) have statistically significant impact upon the cost-performance in the traditional building process.

In terms of relative importance, the two independent variables comprising the 'domain consensus' (*X1* + *X2*) are the least important organizational factors as far as the projects' cost-performance is concerned. The projects' two variables jointly account for only 8.1% of the total variance.

The 'interdependence of tasks' group (*X5* + *X6*) accounts for 17.1% of variance; however, *X5* ('tasks' dependence upon others') alone accounts for 15% and therefore can be considered to be a significant determinant of cost performance. The variables representing the 'Availability and access to information' (*X3* + *X4*), on the other hand, account for over 55% of variance (*X3* = 27.1, *X4* = 28.1) and hence are the most significant variables.

It is obvious that with half of the variables in the model being insignificant, it is not a very efficient model. The stepwise regression removes the three insignificant variables – *X1*, *X2*, and *X6* – from the model and re-evaluates the impact of the remaining three variables.

*A standard score is a standard deviation score. If deviations from the mean, $x = X - \bar{X}$, are divided by the standard deviation of the set of scores, *s*, standard scores are obtained.

‡In propositions where no direction of the relationship between the independent variables and the dependent variable is given, two-tailed significance values must be computed.

Table 1. Determinants of cost-performance

	Dependent variable COST ($X7$)							
	Multiple regression				Stepwise regression			
Independent variables	Coeff. b	B Weight	% Var.	p 1-tail	Coeff. b	B Weight	% Var.	p 1-tail
Constant	1.967	0.000		0.023	2.437	0.000		0.001
Domain consensus:								
$X1$ Clarity of scope of participation	0.074	0.090	5.3	0.257				
$X2$ Specialization	0.033	0.048	2.8	0.366				
Availability access to information								
$X3$ Sufficiency of information	0.367	0.459	27.1	0.005	0.378	0.473	30.1	0.002
$X4$ Time required to procure further information	0.350	0.487	28.8	0.007	0.361	0.504	31.9	0.002
Task interdependence								
$X5$ Tasks' dependence upon others	−0.134	−0.254	15.0	0.063	−0.144	−0.272	17.3	0.036
$X6$ Extent of co-ordination required	−0.019	−0.035	2.1	0.404				
N	21				21			
R Square	0.811				0.795			
p (Regress)	<0.001				<0.001			

Note: ANOVA Result in Appendix 1.

Notice that with the help of $X3$, $X4$, and $X5$, 79.5% of variance in the cost performance can still be accounted for. The two information variables now explain over 62% ($X3$ = sufficiency of given information = 30.1%, $X4$ = time taken to procure further information = 32.1%) of the variance and the 'tasks' dependence upon others' ($X5$), the rest of the 17.3%. The 1.6% loss in the explanatory power of the new regression is more than compensated for by its efficiency.

It is clear from this analysis that in the traditional building process higher cost performance is very significantly dependent upon the sufficiency of and speedy access to needed information, and that greater interdependence of tasks performed by different organizations has a performance lowering effect.

Determinants of time performance

Results of the impact of six organizational variables are tabulated in Table 2. The six variables jointly account for 74.1% of the variance in the project organization's time-performance. Again, the size and the significance of the variance ($p = 0.002$) indicates that the

Table 2. Determinants of time-performance

	Dependent variable COST (*X8*)							
	Multiple regression				Stepwise regression			
Independent variables	Coeff. b	B Weight	% Var.	*p* 1-tail	Coeff. b	B Weight	% Var.	*p* 1-tail
Constant	1.675	0.000		0.074	1.548	0.000		0.064
Domain consensus: *X1* Clarity of scope of participation	0.144	0.169	8.4	0.152	0.194	0.227	12.2	0.58
X2 specialization	0.073	0.103	5.1	0.265				
Availability access to information *X3* Sufficiency of information	0.459	0.552	27.4	0.004	0.414	0.497	26.8	0.005
X4 Time required to procure further information	0.201	0.269	13.4	0.105	0.260	0.349	18.8	0.034
Task interdependence *X5* Tasks' dependence upon others	−0.156	−0.283	14.0	0.071	−0.147	−0.267	14.4	0.070
X6 Extent of co-ordination required	−0.066	−0.117	5.8	0.246				
N	21				21			
R Square	0.741				0.723			
p (Regress)	0.002				<0.001			

Note: ANOVA Results in Appendix 2.

selected organizational variables are very well able to explain the variation in time performance in the traditional building process. It is important to note that while the cost-performance was predominantly influenced by the information variables, time performance is affected by all three categories of variables. The information variables still account for over 40% of the variance, but the others – 'domain consensus' (13.5%) and 'interdependence'

(19.8%) – also fare quite significantly. Furthermore, while *X5* (interdependence of tasks), as predicted, is negatively correlated with the time performance of the project, the fact that *X6* (extent of co-ordination) is also negatively correlated with the time-performance is a surprising result. It seems to suggest (very tentatively, however, as this result is statistically not significant and therefore could have occurred due to chance) that greater co-ordination of tasks in the traditional building process has an adverse effect on the time related performance of the task-organizations. Cumulatively, these two variables underscore once again the unsuitability of the traditional building process for projects where high interdependence of tasks is expected.

The stepwise analysis also includes variables from all three categories in the model. At a loss of 2% in accounting for the total variance, four significant determinants of time performance are identified. They are: 'clarity of the scope of participation' ($X1 = 12.2\%$), 'sufficiency of given information' ($X3 = 26.8\%$), 'time taken to procure further information' ($X4 = 18.8\%$), and 'tasks' dependence upon others' ($X5 = 14.4\%$). While the importance of availability and speed of access to information to time-performance is self evident, the inclusion of *X1* as a significant determinant and the negative direction of *X5* are worth discussion.

In a truly traditional building process, the clarity of the scope of participation would not probably be significant at all, as all the participants are expected to know – indeed know – what is expected of them. That *X1* (clarity of the scope of participation) registers as a significant determinant of time-performance here signals that even in the traditional building process as we know it today, we can no longer assume that everyone knows what he or she is expected to do. This may be a result of the complexity of modern projects where a large number of experts contribute and where, quite often, expertise overlaps while jurisdictions are not precisely delineated. That these uncertainties do not register as affecting the cost-performance is probably attributable to the predominance of lump-sum contracts that underlie the traditional building process.

The inverse relationship between the 'tasks' dependence upon others' and time-performance, on the other hand, could be attributed to the unsuitability of the traditional building process for large and complex projects, as the traditional buildings process characteristically lacks a single co-ordinating authority with a mandate to manage the entire building project.

Determinants of quality-performance

The results of multiple and stepwise regression of the six organizational variables upon the quality-performance are presented in Table 3. Two aspects are immediately noticeable. First, that the six variables jointly account for only 57.1% of the total variance, a low level also reflected in the lower significance level of $p = 0.038$ for the regression. Obviously, it means that the selected variables do not completely explain the quality-performance and that there are other significant factors which must be identified, measured and included in the analysis. Nevertheless, the stepwise regression identifies three variables – 'extent of specialization of task-organizations' ($X2 = 10.7\%$), 'sufficiency of given information' ($X3 = 16.3\%$) and 'tasks' dependence on others' ($X5 = 25\%$) – that account for 52% of the total variance.

The second important aspect of the results is to signal the importance of front-end

Table 3. Determinants of quality performance

	Dependent variable COST (*X9*)							
	Multiple regression				Stepwise regression			
Independent variables	Coeff. b	B Weight	% Var.	*p* 1-tail	Coeff. b	B Weight	% Var.	*p* 1-tail
Constant	4.885	0.000		0.001	4.887	0.000		0.001
Domain consensus								
X1	−0.063	−0.094	3.5	0.325				
Clarity of scope of participation								
X2	0.160	0.285	10.5	0.085	0.153	0.273	10.7	0.062
Specialization								
Availability access to information								
X3	0.234	0.355	13.1	0.077	0.274	0.415	16.3	0.014
Sufficiency of information								
X4	0.100	0.169	6.34	0.267				
Time required to procure further information								
Task interdependence								
X5	−0.221	−0.508	18.8	0.024	−0.278	−0.639	25.0	0.001
Tasks' dependence upon others								
X6	−0.058	−0.131	4.8	0.275				
Extent of co-ordination required								
N	21				21			
R Square	0.571				0.520			
p (Regress)	0.038				0.005			

Note: ANOVA Results in Appendix 3.

decisions to the quality-performance. The inclusion of *X2* (extent of specialization) and *X3* (sufficiency of information) but not of *X4* (time required to procure more information) suggests that the quality-performance is primarily affected by the earliest layouts of the process. In other words, if highly qualified task-organizations are selected and provided with sufficient information about their tasks, then high quality-performance would result. That such highly specialized task-organizations' work also needs to be integrated by some overall co-ordinative mechanism – a characteristic absent in the traditional building process – is evident in the inclusion of *X5* as the most important determinant of quality-performance. It suggests here, just as for cost and time performances, that the high interdependence of tasks in the traditional building process is highly dysfunctional to the quality performance.

Conclusion

An aggregation of the above results reveals an interesting pattern that is presented in Fig. 2. Firstly, the results indicate that at a threshold level the aggregate performance in the traditional building process is primarily affected by two factors: 1. The sufficiency of the

	VARIABLE	COST	TIME	QUALITY
X1	Clarity of Scope of participation			
X2	Extent of Specialization			
X3	Sufficiency of information			
X4	Time required to procure more information			
X5	Extent of Tasks' interdependence			

Fig. 2. Aggregate pattern of results.

starting information, and 2. The extent of tasks' interdependence. It is important to note, however, that 'sufficiency of information' means different things to different participants in the building process. There is evidence (Davidson and Mohsini, 1990) that while the front-end, design-related, task-organizations thrive upon more information, the subcontracting organizations do not. Also, that the second variable – interdependence of tasks – is inversely related to project performance. It suggests, in other words, that the traditional building process without a central integrating mechanism is not very suitable for large and complex building projects.

Beyond the threshold performance, the results suggest that the importance of other variables is goal specific. If the cost efficiency is held important, then a systematic information management system (*X3* and *X4*) and a good interface management system must be devised. Time efficiency, on the other hand, requires that in addition to the systems required for cost control, the process should also have unambiguously defined roles and responsibilities. And, finally, if quality considerations are deemed important then the extent of specialization by the task organizations is the determining factor.

These observations agree with, and indeed systematically confirm, our expectations based on practical experience. However, their greater significance lies in the recommendations that can be drawn from them when attempts are made to modify the traditional building process.

Firstly, as innovative techniques of building, and novel organizational structures that accompany them, upset the required skills needed to interpret instructions (remember the UN-ECE definition of the traditional building quoted earlier in this paper), the availability and access to information will be even more pronounced in the newly emerging procurement processes. A systematic effort to co-ordinate information management, therefore, appears as a prerequisite for successful introduction of innovation and change in the traditional building process.

Secondly, at a practical level, the newer procurement strategies should seek to reduce the negative impact of 'task interdependence' upon performance. In situations where the process-related innovations have the effect to reduce the number of participants – such as where design and manufacture is under a common responsibility, or where the use of complex components and assemblies has eliminated many on-site operations – the interdependence between the task organizations is already a less prominent factor. In other instances where these conditions do not exist, careful integrative and co-ordinative mechanisms must be created.

Thirdly, the importance of specialists should not be ignored. As the building industry is moving into an era of rapid absorption of innovations and has to deal with increasing demands of higher quality, the importance of the degree of specialization as a determinant of performance is likely to increase. Thus, we appear to have a blue-print for innovation and change in the traditional building process, where information (its quality and availability, along with process aggregation and greater specialist intervention) can lead to improved time cost and quality performance.

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Appendix A

ANOVA results for independent variable 'COST' (X7)

ANOVA – multiple regression

Source	Sum-of-Square	DF	Mean-Square	F-Ratio	P
Regression	9.926	6	1.654	9.981	0.000
Residual	2.321	14	0.166		

ANOVA – stepwise regression

Source	Sum-of-Square	DF	Mean-Square	F-Ratio	P
Regression	9.740	3	3.247	22.020	0.000
Residual	2.507	17	0.147		

Appendix B

ANOVA results for independent variable 'TIME' (X8)

ANOVA – multiple regression

Source	Sum-of-Square	DF	Mean-Square	F-Ratio	P
Regression	9.839	6	1.640	6.686	0.002
Residual	3.433	14	0.245		

ANOVA – Stepwise regression

Source	Sum-of-Square	DF	Mean-Square	F-Ratio	P
Regression	9.591	4	2.398	10.421	0.000
Residual	3.681	16	0.230		

Appendix C

ANOVA results for independent variable 'QUALITY' (X9)

ANOVA – multiple regression

Source	Sum-of-Square	DF	Mean-Square	F-Ratio	P
Regression	4.744	6	0.791	3.102	0.038
Residual	3.568	14	0.255		

ANOVA – stepwise regression

Regression	4.322	3	1.441	6.139	0.005
Residual	3.990	17	0.235		