The role of managerial actions in the cost, time and quality performance of high-rise commercial building projects

Article *in* Construction Management and Economics · January 1983

Construction Management and Economics, 1985, **3**, 59–87

The role of managerial actions in the cost, time and quality performance of high-rise commercial building projects

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An analysis of the effects of managerial actions on the objectives of reducing time, reducing cost and increasing quality is undertaken. This approach is proposed as contributing to a rationale for action in the building process. A sample of 25 high-rise office buildings was used to test this theory and the results analysed by partial correlations and multiple regression.

Increases in construction planning during design and co-ordination across the design–construction interface are shown to have very strong effects on reducing construction time and increases in the former variable, which also included aspects of value analysis, reduce the cost of the building. However, increases in variations to the contract, the complexity of the building, the number of storeys and the extent of industrial disputes are shown to strongly increase construction time. At the same time the building cost is increased by increasing variations to the contract, the architectural quality and the number of nominated sub-contractors. Increases in architectural quality are shown to occur through generating more alternative designs, increasing the cost per square metre and planning the construction process as part of the design, the last of which included some value analysis.

A methodology which could be used on an extended sample is proposed.

Keywords: Cost, time, quality, building process, buildability, variations, contingency theory, coordination.

Introduction

This work addresses the question of how to choose the best methods of managing high-rise commercial building projects. Initially a broader problem was considered, but when the nature of the problem became clear it seemed that the approach had to be restricted to a particular building type and purpose.

The term 'building process' is used here for the total process from owner contemplating building, through the design and construction phases, to completion. This work will be concerned with the management of the whole process including the relationships with the proprietor, the responsibilities of consultants, the communication patterns, the timing of decisions and the choice of techniques to assist decision making. How designers arrive at design decisions, the form of and relationships between spaces and many other design aspects, will not

0144–6193/85 $03.00+.12

be considered as part of the management aspect: see the RIBA distinction between design and management functions as a guide (RIBA, 1980).

Guidance on how to choose the best methods of managing the building process may be required as no clear direction is available to those making management decisions, there have been numerous criticisms of the practices that have been used in the past and there have been a number of apparent failures of the management of the process. Clear guidance is not available to owners or practitioners on which way the building process should be managed as numerous procurement methods are available, such as lump sum, package deal, construction management and project management. However few studies are available to assess the relative merits of each: Wood (1975), NEDO (1983) and CIRIA (1983) being exceptions.

Modelling the process of producing buildings

Structural questions

The structure of the building process should be studied in order to show which structure is appropriate for particular project environments: commercial or government, large or small, simple or complex. Furthermore, specific building types, e.g. office, industrial and domestic, will influence the structure chosen. This study is important in terms of advancing contingency theory because there has been little work on the relationships between structure and environment for project organizations.

Project organizations

Organizations that are characteristic of building projects are extreme compared with other organizational forms. They fall into the group defined by Mintzberg (1979) as the 'adhocracy'. Some of their characteristics are:

They are assembled to produce the building and disbanded when the task is complete.

They have little scope for developing systems to optimize performance as only one product is produced.

Distinctly different specialists are brought together in a team with few representatives of each specialism.

Choices of structure apparently available

There is currently available, within building industries world-wide, a range of apparently different ways of structuring the organization of the project team. These are called contractual arrangements or procurement methods; examples of these are lump sum, package deal and construction management. Smith (1975) and Ahuja (1980), amongst others, have attempted to compare these methods pointing out the advantages of each in achieving particular objectives.

Procurement methods can not be adequately defined and are not discrete as there are inherent in each method a number of variables, many of which can take virtually any value in a procurement method, while only a few are unique to any particular procurement method. Thus it is impossible to make formal comparisons of the effectiveness of procurement methods. (See Appendix A for the argument substantiating this assertion.)

Attempts to map structure

Some major research has been attempted to clarify the structure of the building process:

Turin (1968) described the process in terms of four basic processes showing the flow of decisions and the changing source of authority during the process.

Irwig (1980) isolated four structural methods, however there is no apparent relationship between the models of Turin and Irwig.

Walker (1981) defined a model common to all projects, which is client-oriented and in terms of the three stages of project conception, project inception and project realization. Subsystems exist within each of these primary systems of activity. Decision points within the system lead to discontinuity and a parallel management system operates. This study, relating objectives to managerial actions, explores this last management system.

Sidwell (1982) formulated a model general to all building types, linking client characteristics, project characteristics, project procedures and the structure of the building team, and the correct structuring of these in terms of cost and time.

Measures of success

These studies have used measures of efficiency which seem too general. Baker *et al.* (1976) used a general measure of project success while Sidwell (1982) used measures of satisfaction on time and on cost which require subjective judgement by the client which is likely to reflect his background as much as real success. More objective measures of success are required.

An approach to modelling

Contingency factors operating in projects

To identify the contingency factors that affect the choice of project structures the model of Kast and Rosenzweig (1973) is useful as a general paradigm. This portrays organizations in terms of technological, goals and values, psychosocial, managerial and structural subsystems. While Kast and Rosenzweig see these subsystems as interdependent, it is reasonable to view structure, management, psychosocial and technology as independent variables leading to the dependent variable of goal achievement. Extending this idea further, decisions taken on structure, management, psychosocial aspects and technology can be seen as managerial actions which lead to the achievement of objectives.

Proposed model

A useful contribution to modelling the building process may be to investigate the relationships between the use of particular managerial actions, or managerial approaches, and their effects on the achievement of goals or objectives.

Chosen objectives

A number of authors have listed objectives considered important in construction projects. Many of these hinge on cost, time and quality aspects, and hence the following objectives are chosen for investigation:

to reduce the cost of the building
to reduce the time of construction
to increase the architectural quality

These objectives are in relative terms because there are no bench marks on which to base ultimate performance on these aspects.

Identification of variables and their effects on cost, time and quality

Technological effects

The main technological effects studied have arisen from the inherent complexity and uncertainty within the building process.

The inherent complexity is composed of:

technical complexity (Woodward, 1965; Zwerman, 1970)
interdependence of work flow (Hickson *et al.*, 1969)
analysability (Mohr, 1971)
task difficulty (van der Ven and Delbecq, 1974)

The uncertainty is composed of:

unfamiliarity (Burns and Stalker, 1961; Sadler *et al.*, 1973)
uncertainty (Thompson, 1967; Lawrence and Lorsch, 1967)
lack of routine (Hage and Aitken, 1969)
lack of predictability (Harvey, 1968)

The interpretation of these technology variables in the design and construction of building projects is given below. These can be seen as hypotheses, which are summarized in Table 1.

Time overlap of design and construction. This variable or managerial action is an aspect of complexity since construction is commenced before design is completed. Although it could be expected that the overall time required for both processes would be reduced in this way the actual construction time and cost is expected to increase in comparison with projects where this did not occur. Quality is also expected to be impaired.

Use of provisional or partial quantities. The practice of awarding the construction tender to a contractor, or contractors, on the basis of a bill of quantities that is representative, and hence

Table 1. Summary of hypothesized effects of variables on the achievement of objectives.

I = Increase; R = Reduce

Variable	Effects on COST	TIME	QUALITY
Technological effects			
Time overlap of design and construction	I	I	R
Use of provisional or partial quantities	R	R	—
Complexity of form of construction (COMPINDX)	I	I	I
Variations to the contract (CONTVAR)	I	I	I
Structural effects			
Use of nominated subcontractors (NOMSCONT)	I	I	I
Use of a construction manager	R	R	—
Use of a project manager	R	R	—
Use of a single co-ordinator	—	R	—
Allocation of responsibility for the whole process to the contractor	—	R	R
Construction co-ordination (CONCOORD)	—	R	—
Design-construction interface co-ordination (DCOORD2)	—	R	—
Use of time control	—	R	R
Use of cost monitoring during design	R	—	R
Quality control on site (SITEQC)	—	—	I
Number of site managerial personnel	—	R	—
Use of more-competent-than-average designers	R	R	I
Use of more-competent-than-average construction management personnel	R	R	I
Psychosocial effects			
Number of days lost through industrial disputes (DISPUTDA)	—	R	—
Managerial effects			
Competition at tender	R	I	R
Use of select tendering	I	—	I
Construction planning during design (CPDD)	R	R	R
Generation of alternative designs (GAD)	R	—	I

provisional, or which is not completed, and hence partial, is not uncommon for major building projects. This is done to allow a building contractor to contribute to the design process. Contractors are normally unlikely to be instrumental in increasing architectural quality but are expected to assist in reducing cost and time.

Complexity of the form of construction (COMPINDX). The inherent complexity of the form of construction arises from, e.g. the use of abnormally long spans for beams or slabs, or the use of unusual materials or processes. It is expected that this will lead to increased cost and time along with architectural quality.

Variations to the contract (*CONTVAR*). Varying the design of the building after construction has commenced is disruptive as planned construction processes have to be varied. This is expected to increase cost and time, but may increase the quality. This is not an obvious managerial action although it can be seen as lack of managerial control and thus lack of action. Hence many project groups ensure that the value of variations are purposely kept below certain limits.

Structural effects

Structure was seen by Hickson *et al.* (1969) to be composed of:

specialization	centralization
standardization	configuration
formalization	flexibility

It was also seen to be composed of:

co-ordination (Thompson, 1967; Sadler *et al.*, 1973)
control (Sadler *et al.*, 1973)

Thus, phenomena occurring in the building process that are aspects of structure are given below.

Increased use of nominated sub-contractors. Sub-contractors are often nominated by the architect and proprietor to the main contractor in order to ensure a better quality construction or assist the design team. Architectural quality (QUALITY), building cost (COST) and construction time (TIME) are all expected to increase.

Use of a construction manager. A construction manager can provide advice on the buildability of the project or act as a co-ordinator and controller of cost and time aspects. It is expected that the use of a construction manager will lead to reduced TIME and COST for major buildings.

Use of a project manager. Results similar to those for the use of a construction manager are expected.

Use of a single co-ordinator. The greater co-ordination provided by the use of a single co-ordinator or co-ordinating organization, as opposed to two or more co-ordinating organizations, is expected to lead to reduced TIME.

Allocation of responsibility for the whole process to the contractor. The allocation of responsibility for the whole process to the contractor is expected to lead to reduced TIME. However, due to the movement of responsibility away from the architect, reduced QUALITY is also expected.

Increased co-ordination. Co-ordination has always been seen as an aspect of the structure of organizations. For this study co-ordination is defined as the integration of the activities of individuals by getting them together to relate the facets of the problem that concern each of them to other facets. This involves keeping people informed of the progress of the job, especially if any changes occur. Co-ordination is one method used to ensure control, that is, keeping to schedules, cost-plans and the client's requirements.

Co-ordination in the building process is composed of three distinct aspects:

The co-ordination of the design team before construction (design co-ordination (DESCOORD)).

The co-ordination of the construction team during construction (construction co-ordination (CONCOORD)).

The co-ordination of the design and construction teams at the design–construction interface (design–construction interface co-ordination (DCOORD 2)).

The latter two are expected to reduce TIME.

The use of time control. Time control is defined as the control of the actions of the participants in the building process in order to adhere to the agreed schedule. The introduction of a project schedule, from the feasibility stage, will have a strong effect on reducing the time taken for design and construction. An ambitious project schedule can be produced from experience or historical records and used as the basis of control. A network of activities for both design and construction can be measured against the schedule and adjustments made as required to adhere to the schedule.

An important part of the control process is the assessment of the implications of construction time on design decisions. This means changing the decisions if the design produced will take too long to construct. Increased time control is expected to not only lead to reduced TIME but also to reduced QUALITY.

The use of cost monitoring during design. For cost control of a project to be satisfactory it is essential that the budget generated at the feasibility study be translated into a detailed cost plan which is then used as a control document as the design evolves (Ahuja, 1980). One way of assisting the process is by establishing the budget before the designers are appointed and then writing the budget into their conditions of engagement (Weinberg, 1978; Flanagan, 1979). The established budget can be ruthlessly applied by forcing design amendments whenever the estimated cost of the design exceeds the budget. If this occurs one would expect COST to be reduced due to greater degrees of cost monitoring during design. One would also expect QUALITY to be sacrificed.

Quality control on site (SITE QC). Greater degrees of quality control on site are expected to lead to increased QUALITY of the finished building. Although this may lead to increased COST and TIME the effects are likely to be negligible.

Number of site managerial personnel. The number of personnel used on site to co-ordinate, supervise and generally manage the construction process will affect the speed of construction.

On average the number of site managerial staff is too few, and hence an increase in the number of site management staff could reduce the TIME.

Use of more-competent-than-average design team members. If design team members were more competent than average then all three objectives of reduced TIME, reduced COST and increased QUALITY may be achieved.

Use of more-competent-than-average construction management personnel. If construction managerial personnel were more competent than average then all three objectives of reduced TIME, reduced COST and increased QUALITY may be achieved.

Psychological effects

The psychosocial subsystem is concerned with the behaviour of people in the organization both as individuals and in groups. This can include:

motivation (Maslow, 1943; Herzberg, 1966; McGregor, 1960)
interests of members of groups (Cyert and March, 1963)

The psychosocial effects on the management of projects are numerous but are restricted in this study because none of the other aspects are of similar relative importance.

Creation of a productive industrial climate. The creation of a productive industrial climate should obviously be a goal within any project organization. What this constitutes is much more difficult to determine, and industrial relations is a major study that will not be explored here. However, the number of days lost during the TIME will be recorded to measure this variable by reference to all other managerial actions.

Managerial actions

Kast and Rosenzweig (1973) saw the managerial subsystem spanning 'the entire organization by relating the organization to the environment, setting the goals, developing comprehensive strategic, and operational plans, design the structure and establish control processes'. While choosing the appropriate structure, satisfying correct goals and the like are part of the management role, there are also specific tasks that appear to be managerial rather than otherwise.

Competition at tender. Competition among prime contractors for the whole of or for major parts of the work is expected to reduce COST. Bromilow (1971) found this to be so. However, the fact that contractors are being chosen on the basis of cost rather than time and quality suggests that these latter two objectives are less likely to be achieved if competition occurs.

The use of select tendering. Open tendering has been criticized in a number of reports (Banwell, 1964) because by letting all-comers tender for the work, a contractor is likely to be chosen who has low standards of craftsmanship. By contrast, in selective tendering only those contractors with a reputation for good quality and good time performance are invited to tender.

Therefore, a slight increase in QUALITY and in COST is expected when selective tendering is used by comparison with the industry average.

Construction planning during design (CPDD). This managerial action is the consideration of methods and processes of erecting the building as part of the design process, and is an attempt to achieve a form of construction which can be erected in as efficient a sequence of actions as possible. In some design teams, consideration of sequences of activities on site, the handling of materials, the appropriate use of plant and equipment and the analysis of labour on a detailed basis does occur as part of the design process. In other design teams such considerations are seen to be more suitable for the contractor after the tender has been won.

Construction planning during design is expected to reduce TIME. Due to the fact that buildability considerations are likely to outweigh aesthetic considerations, reduced QUALITY is also expected.

Generation of alternative designs (GAD). The degree of generation of alternative designs is systematically compared for their relative ability to satisfy objectives. While the achievement of all objectives is expected to be enhanced by this managerial action, a reduction in TIME is normally associated with CPDD rather than an almost random generation of designs. An increase in QUALITY and a reduction in COST is also expected. GAD normally occurs in discrete stages, in that overall massing of the building may be compared, then aspects of parts of the building, such as core arrangements, typical floor layouts and facade treatment.

Summary of the effects of variables on cost, time and quality

The hypothesized effects of the variables, discussed above, are summarized in Table 1.

Testing the model

The propositions discussed above form a basis for extension with further work into a model, provided testing of the model leads to positive results.

Testing approach

The propositions are tested by the partial correlations and multiple regressions: partial correlation is used to show that associations occur between variables and to indicate the probability of the associations; multiple regression is used to show the relative strengths of the effects of the variables. Partial correlations is a particularly useful, rigorous method of analysis for showing that two variables are associated, that is, as one variable increases the other variable also increases, or, as one variable increases the other variable decreases. However, a potentially misleading aspect of any correlational approach is the apparent correlation between any two variables which is caused by each separately being correlated with a third. Such misleading associations do not occur when partial correlation is used as the effects of other variables are controlled statistically (Nie, 1979, p. 303). The partial correlational analysis is done using the *Statistical Packages for the Social Sciences* (Nie *et al.*, 1979).

In each case the SPSS programme is used to control for all other variables that had significant correlations with the two being partially correlated. Thus misleading correlations are likely to be eliminated.

The multiple regression analysis shows the strength of relationships between variables, especially the relative effects of the particular managerial actions on the achievement of objectives. This was also achieved using the *Statistical Packages for the Social Sciences.*

The sample data

The number of storeys (NOSTORY) was from 14 to over 50. Most of the buildings were completed in the 1970s with two of the sample completed prior to 1970. All buildings were of a reinforced concrete frame and were erected for the prime purpose of investment. Four buildings had shopping arcades at lower levels to a maximum of three. The nominal procurement method used is as follows:

Of five traditional projects, two had a management consultant as part of the design team.

In 9 of the 14 'traditional' projects the contractor was chosen before documentation was completed. The choice was based on either tendering, preliminaries and profits or a provisional bill of quantities. A management consultant advised on many projects.

Four projects were initiated by a building contractor who initially employed the consultants. However, in each case the building was sold during the course of construction.

Seven projects were managed by one firm of package-deal project managers. In all but one of these architects in private practice were employed.

The sample represents

21 proprietors
8 contractors
17 architects

Many projects were started in the early 1970s and very few in the late 1970s. Therefore, the sample tended to be confined to those projects on which records have been kept for at least the five years since completion. The sample is not random. As there is not a large enough pool of potential projects from which to choose, it is not intentionally biased.

The questionnaire used

Apart from gathering general information about projects the questionnaire was used to measure some of the variables which could not be measured by direct interval level measures (see Ireland, 1983). The questionnaire was self-administered by the person in charge of each project, who was the architect in all but the package deal projects. Some of the answers could not be remembered, in which cases another consultant or the contractor was asked to provide the answer. This happened on less than 1% of questions.

This approach is expected to introduce error into measurements as memory acts selectively (see Moser and Kalton, 1971). However, the *SPSS* package does allow standard errors to be calculated and hence controlled. If errors are too large the stability of the multiple regression equations and partial correlations breaks down and these are not reported.

Selection of measures for variables from the questionnaire

Not all questions were equally useful for measuring the variables. All the questions that were used to measure a variable were correlated with the sum of the values for the relevant questions as proposed by Youngman (1979). Those that had either low or negative correlations were then eliminated (Cronbach, 1970). The Cronbach α is a measure of the reliability of any variable measure and is the lower bound of the split-half reliability. Youngman (1979) considers this to be better than other arbitrary split-half results and accepts values over 0.70 as satisfactory.

On average nine questions were selected to measure each variable. As an example, some of the questions used to measure CPDD are given below. In each case two points were scored if the activity occurred during design development, one point if it occurred during the working–drawing stage and no points if after.

When were items that were likely to be delayed beyond the promised delivery date identified?
When was the route of materials handling on the construction site analysed?
When were the types of hoisting equipment to be used for erection analysed?
When was the safety of site operatives analysed?
When were potential demarcation problems analysed?

The Cronbach α scores of reliability for variables used were all in excess of 0.74.

Managerial actions that could not be tested

A number of managerial actions could not be tested in the case studies for a variety of reasons. These are shown in Table 2.

Results

Partial correlations

Zero order correlations were found between all independent variables and a particular dependent variable. The partial correlation between an independent and a dependent variable was then found after all other independent variables had been partialled out. The results of analysing the partial correlations follow. There is evidence to suggest that the effects are causal.

Construction time per square metre (TPSM).

(a) DCOORD2 is associated with a reduction in TPSM at the 0.05 level with all relevant variables partialled out.

(b) CPDD is associated with a reduction in TPSM at the 0.05 level provided the accompanying reduction in cost is not partialled out and the accompanying increase in DCOORD2, through CPDD, is not partialled out.

Table 2. Managerial actions that could not be measured in the case studies.

Variables that could not be tested	Effectively no variation within sample	Poor records	Poor measurement	No measurement
Competition at tender		*?	*?	
Selective tendering	*			
Use of provisional or partial quantities			*	
Overlap of design and construction			*	
Use of a single co-ordinator	*			
Allocation of responsibility for the whole process to the contractor	*			
Use of construction manager	*			
Use of a project manager	*			
Use of time control			*	
Cost monitoring during design	*?		*?	
Use of more-competent-than-average design personnel				*
Use of more-competent-than-average construction personnel				*

* Reason for inability to be tested.
*? Possible reason for inability to be tested.

(c) COMPINDX is associated with increased TPSM at the 0.05 level provided the additional building cost per square metre (CPSM) is not partialled out.

(d) Gross area (AREA) is associated with a reduction in TPSM at the 0.05 level when all relevant variables have been partialled out.

There is also evidence that disputes per unit of time (DIPT) and NOSTORY may be associated with increased TPSM at the 0.05 level if analysed in a larger sample.

Building cost per square metre (CPSM).

(a) Contract variations per unit of building cost (CVPC) are associated with an increase in CPSM at the 0.05 level when all relevant variables have been partialled out.

(b) QUALITY is associated with an increase in CPSM, at the 0.05 level although this may be through increases in CVPC.

(c) CPDD is associated with a reduction in CPSM, at the 0.05 level although it is partly through increases in DCOORD2.

There is also evidence that COMPINDX may be associated with an increase in CPSM and DCOORD2 may be associated with a decrease in CPSM if investigated in a larger sample. It seems that (a) and (c) are causal. With regard to (b), it is not possible to determine whether increases in QUALITY cause CPSM to be increased or vice versa, although they certainly accompany each other.

Architectural quality (QUALITY).

(a) GAD is associated with increases in QUALITY at the 0.05 level although the association does not hold if CVPC is partialled out.

(b) CPDD is associated with increases in QUALITY at the 0.05 level although the association does not hold if CVPC is partialled out.

(c) CPSM is associated with increases in QUALITY at the 0.05 level although this may be through increases in CVPC.

(d) CVPC is associated with increases in QUALITY although the association does not hold if CPSM is partialled out.

There is evidence to suggest that (a) and (d) are causal. With regard to (b), it is considered that the increased attention given to the design while CPDD is occurring, leads to design improvements being shown.

Strengths of variables

The strengths of the managerial actions on each of TIME, TPSM, CPSM and QUALITY are shown below. All of these were significant at the 0.05 level or better. Because of some missing values in the measurement of some variables, regression runs on various subgroups from within the sample produced different equations.

Construction time.

23 cases

TIME = 581.8 + 22.6 COMPINDX − 28.7 CPDD + 79.0 AREA

S.E. =	12.3	5.5	25.0	$R^2=0.73$ adj.
β =	0.31	−0.63	0.56	

16 cases

TIME = −38.9 + 21.2 COMPINDX + 16.5 DIPT − 24.6 CPDD + 90.3 AREA

S.E. =	12.8	3.7	5.7	26.7	$R^2=0.88$ adj.
β =	0.31	0.51	−0.53	0.74	

10 cases

TIME = −434.3 + 50.2 COMPINDX + 15.1 DIPT

S.E. =	9.7	4.8	$R^2=0.77$ adj.
β =	0.84	0.52	

Construction time per square metre.

23 cases

TPSM = 441.5 − 22.6 DCOORD2 − 99.4 AREA + 18.5 COMPINDX + 46.8 NOSTORY

S.E. =	7.4	27.8	9.1	27.0	$R^2=0.61$ adj.
β =	−0.48	−1.13	0.40	0.50	

16 cases

TPSM = 318.6 − 23.3 DCOORD2 − 99.4 AREA + 26.3 COMPINDX + 43.3 NOSTORY

S.E. =	12.1	28.5	11.0	22.5	$R^2=0.72$ adj.
β =	−0.48	−1.36	0.65	0.58	

10 cases

TPSM = 155.4 + 6.7 DIPT − 23.0 CPDD + 2924 CVPC

S.E. =	1.7	4.1	544	$R^2=0.91$ adj.
β =	0.44	−0.75	0.63	

Building cost per square metre.

23 cases

CPSM = 3.41 + 0.061 QUALITY	− 0.082 CPDD	+ 0.065 COMPINDX		
S.E. = 0.017	0.026	0.041		$R^2 = 0.47$ adj.
β = 0.61	−0.52	+0.25		

10 cases

CPSM = 1.23 + 0.053 GAD	+ 22.8 CVPC	+ 0.41 NOMSCONT	− 0.11 CPDD	
S.E. = 0.02	3.7	0.10	0.029	$R^2 = 0.90$ adj.
β = 0.31	0.81	0.58	−0.60	

Architectural quality.

QUALITY = −22.2 + 0.62 GAD	+ 5.3 CPSM	+ 0.62 CPDD	
S.E. = 0.31	1.63	0.26	$R^2 = 0.52$ adj.
β = 0.33	0.53	0.39	

In each case the β value for each managerial action shows the proportion of one standard deviation change in the dependent variable made by a one standard deviation increase in the managerial action. Examples of the effects of each managerial action on the achievement of objectives are shown below.

Relationships between cost, time and quality. To gain some appreciation of the interactions of COST, TIME and QUALITY, multiple regressions were conducted on each of these in terms of the other two. Some physical measures such as area and number of storeys were also included. The following results were produced.

$$\text{TIME} = 219\ \text{COST}^{0.47}$$
$$R^2 = 0.58,\ p = 0.001$$
$$\text{COST} = -15.7 + 7.2\ \text{AREA} + 0.0147\ \text{TPSM} + 0.14\ \text{QUALITY}$$
$$R^2 = 0.95,\ p = 0.05$$
$$\text{CPSM} = 1.7 = 0.0043\ \text{TPSM} + 0.037\ \text{QUALITY} + 0.22\ \text{AREA}$$
$$R^2 = 0.56,\ p = 0.005$$

Relative strengths of managerial actions

Examples of effects of managerial actions on construction time

While it is not possible to statistically relate the effects of each managerial action for the separate sets of cases shown earlier, it is possible to gain some notion of the relative effects by taking (mean TPSM) × (mean AREA), thus giving a notion of mean time. The reductions or additions to construction time are shown in Table 3.

Examples of effects of managerial actions on building cost

One can gain some notion of the relative effects on COST of a one standard deviation increase in each managerial action. These are shown in Table 4.

Please note that cost monitoring during design was assumed to be equally well applied on all projects because experienced practitioners were engaged and a full cost monitoring service used. However, this managerial action could have played a strong role and deserves a more careful measurement.

Table 3. The changes to TIME associated with a one standard deviation increase in each of the managerial actions assuming each change is made independently of others.

Variable	Effect (in days)
CPDD	494 decrease
CVPC	415 increase
NOSTORY	309 increase
COMPINDX	297 increase
DCOORD2	297 decrease
DIPT	290 increase

Note: TPSM × mean AREA = 1077 days.

Table 4. The changes to mean COST associated with a one standard deviation increase in each of the managerial actions assuming each change is made independently of the others.

Variable	Effect (in $ million)
CVPC	0.983 increase
QUALITY	0.766 increase
NOMSCONT	0.704 increase
CPDD	0.653 decrease
GAD	0.376 increase
COMPINDX	0.314 increase

Note: (mean CPSM) × (mean AREA) = $14.37 million.

Effects of managerial actions on QUALITY

The relative effects on QUALITY of making a one standard deviation change in each managerial action are shown in Table 5. As there are no obvious units for QUALITY this is expressed as a relative increase in the ranking of the 23 buildings.

Interpretation of results

The equations from the multiple regression analysis and the results of the partial correlations lead to both useful conclusions and practical results. While no scientific method can fully demonstrate causality the rigorous analysis provided by partial correlations provides strong evidence confirming causality, which is also confirmed by multiple regression analysis.

The β values shown in the equations indicate the relative strengths of the managerial actions on cost, time and quality results. To convert questionnaire values into scales that can be used to

Table 5. Changes to the ranking of buildings for QUALITY associated with a one standard deviation increase in each of the managerial actions assuming each change is made independently of the others.

Variable	Improvement
CPSM	4.1
CPDD	3.0
GAD	2.6

predict cost, time and quality results is not possible until a larger and demonstrably random sample of projects is surveyed.

Conclusions

A methodology has been developed which can be seen at greater length in Ireland (1983). It has been shown that it is possible to relate managerial actions to the achievement of objectives for high-rise commercial building projects. Further work can be done to enlarge the sample and refine the measuring techniques.

The effects of specific managerial actions on the achievement of the objectives of reducing COST, reducing TIME and increasing QUALITY are shown together with the relative effects. The very strong influences are shown below in descending order of effect.

Objective	Managerial action
To reduce TIME	Increased CPDD
	Reduced CONTVAR
	Reduced NOSTORY
	Reduced COMPINDX
	Increased DCOORD2
	Reduced DIPT
To reduce COST	Reduced CONTVAR
	Reduced QUALITY
	Reduced NOMSCONT
	Reduced COMPINDX
	Increased CPDD
To increase QUALITY	Increased CPSM
	Increased CPDD
	Increased GAD

The best predictor of average construction time of high-rise commercial buildings is $T = 219C^{0.47}$. Emphasizing managerial actions which were found to affect time, cost and quality will lead to more efficient projects.

Appendix A

Procurement methods

Distinctions between methods. A 'procurement method', or 'contractual arrangement', is a term used to describe the management approach and the conditions of contract in use on building projects. Procurement methods are defined as the overall management structure and specific management practices in use on a project. These are determined by the roles played by the participants as well as the formal contracts used. The term 'procurement method' has the sense of describing the roles of participants, the relationships between them, both formal and informal, the timing of events, and the practices and techniques of management that are used. Examples of procurement methods are: a single lump sum contract on a fully documented project; provisional or partial quantities; cost reimbursement; package deal; construction and project management. It has become fairly common for practitioners to use such terms to describe and define a set of practices that occur during the management of building projects. (See also Ferry and Brandon, 1980; McCanlis, 1967; Smith, 1975; Business Roundtable, 1982.) However, virtually meaningless distinctions are suggested. Therefore a more precise, although more cumbersome, practice for use in describing what is occurring in a procurement method, would be to define what is occurring on a number of variables.

Methods in common use

A single lump sum contract on a fully documented project. This method is characterized by an architect being approached by a proprietor with a request to assemble a team of professional specialists to design and fully document the future building. A contractor is then chosen and a price determined, either by competitive tendering or by negotiation, and a contract signed. The building is then constructed. Any variations to the contract that may be required are handled by adjusting the total price at rates shown in the priced bill of quantities. The architect is normally responsible for managing the process before the contractor is appointed, with the role of protecting the interests of the proprietor, on the one hand, and acting as intermediary between the proprietor and the contractor, on the other.

Provisional or partial quantities contracts. The design team is assembled in a similar manner to the lump sum contract. However, the work to be done by the contractor is measured and priced at the rates stated in a bill of approximate quantities or a schedule of prices prepared by the quantity surveyor, based on a similar project. Normally the design is not completed at the time of letting the contract. The actual price paid is determined by measuring the actual amounts of work done and paying these at bill rates as are variations. The contractor often provides some advice on buildability in the latter stages of the design process. When a partial bill is used the competition is based on firm quantities for part of the project.

Cost reimbursement (cost-plus). The contractor, or contractors, are paid the cost of the work completed plus a fee. The fee may be a percentage of the cost of the work or fixed. Cost-plus was favoured in the past as it had the considerable advantage of allowing the owner to make decisions as work progressed. It is now mainly used when construction must be carried out so quickly that design cannot be completed before construction commences. Normally documents are not completed for the whole project before work commences.

Package deal (design and construct or turnkey). A package deal, or design and construct, contract is a single financial transaction under which one person or organization designs and builds to the firm order of the customer. The contract is signed before the building has been defined by full documents. However, in order to make a contract, a brief specification and some sketches are usually prepared. Normally the design is not fully completed before construction commences. While a bill of quantities is not normally prepared, variations are priced according to a schedule.

Construction management. Construction management as a procurement method can take many forms, two of which are described below.

Method 1. The construction manager acts as a consultant to an independent architect during the design phase, in order to clarify the time and cost consequences of design options as they occur. During the construction phase, he co-ordinates and directs all the construction activities. As this method is usually used where a number of prime contractors are both simultaneously and sequentially involved in the construction, the construction manager also advises on the method of obtaining contractors, awarding contracts and packaging the design documents. Thus several contracts are made directly with the proprietor as a general contractor is not engaged. However, the construction manager does not receive any part of the profit for the project, and does not accept any major risk. The primary responsibility is for adherence to the construction programme and the construction cost budget.

Method 2. The construction manager is a general contractor who provides consulting services at the same time as acting as a general contractor during the construction phase. The construction contract is likely to be on a cost-reimbursement basis and can have optional guaranteed maximum cost, liquidated damages for late completion, bonuses for early completion or a savings incentive clause.

Project management. Project management can be a separate procurement method when a project manager is appointed as the person responsible for managing the design and construction phases. During design and construction, the consultants, such as architects, engineers, quantity surveyors, etc., take their places as members of the team managed by the project manager. Often a construction manager would be part of the team as well. Frequently there is considerable overlap of design and construction, and multi-contracts are made directly with the proprietor.

Differences between procurement methods. It is suggested that there are four essential differences between the procurement methods which are based on:

1. The arrangements for determining the cost of the project and identifying the contractor to be used.
2. The roles and relationships of the specialists used including the possibility of having the contractor available to contribute to the design.
3. The process structure adopted, including such aspects as the overlap of design and construction, the use of multiple prime contracts and the staging of these.
4. Details included in the conditions of contract such as provisions for extensions of time for industrial disputation or inclement weather, etc.

Arrangements for determining cost. Two extremes exist for determining cost:

1. A fixed and firm price tendered by the contractor, or contractors, to complete the work, the price being firm no matter what contingencies, such as cost or industrial disputes, arise.
2. A cost-reimbursement arrangement by which the contractor, or contractors, are reimbursed for all of their costs plus an additional percentage or fee.

These two extremes have been broken down by combining their features, for example:

1. Provisional or unit price contracts may be made in which the contractor tenders on firm prices for units of work, the extent of the work in each unit being indeterminate at the time of tender.
2. Fixed prices are made on packages of work, the number of packages being indeterminate at the commencement of the work.
3. Provisional and prime cost sums are included in the fixed price contract to cover work not yet fully defined.
4. Exceptions to the fixed price are for aspects such as escalation of costs in labour and/or materials; compensation for industrial disputes or inclement weather; and variations to the extent of the work.

Process of selecting the contractors. Price determination is often combined with determining which contractor will be used. In competitive tendering this is certainly so; however, the proprietor may negotiate a price with a contractor of his choice and thus separate the two aspects.

The roles of specialists. The roles taken and relationships between the specialists have become a basis for a difference between procurement methods. For example, Construction Management *Method 1* can be fairly similar to the lump sum contract, except that a construction methods specialist has been introduced at the design phase to advise on aspects of buildability, the acceptance of tenders and the packaging of work.

The differences between construction management, project management and a package deal is partly concerned with the roles of the specialists. Another aspect of the roles and responsibilities of specialists is the question of whether the contractor shall be available to contribute to the design. Procurement methods such as package deal and provisional quantities were introduced partly for the contractor to be available during this phase.

Process structure. This variable includes general considerations concerning the structure of the process, for example:

Whether the project is fully designed and documented in drawings and specification at the time of commencing construction.
The number of contracts used directly between the contractors and the proprietor.
Whether the contracts are let progressively or all at once.

Conditions of contract variables. This variable includes a number of minor matters which are included in the conditions of the contract. These could vary from project to project.

Variables are not isolated. The variables associated with the five aspects used to describe procurement method variables are shown in the left hand column of Table A1. Most variables have a range of values. Many are independent.

Methods of describing procurement methods.

Use of variables to describe procurement methods. The procurement variables can be used to present a detailed picture of what is occurring with respect to the procurement method on a particular project by specifying the extent to which each variable occurs. This method, although more cumbersome than the simple use of the procurement method titles, does indicate the real picture concerning the management of a project.

Lack of unique descriptions in procurement method titles. By examining the occurrence of a variable in each of the procurement methods in Table A1, it can be shown that the sets of actions encompassed by the procurement method titles are not discrete. If a variable never or always occurs in a particular procurement method, and this is never or always by itself in a row, a unique aspect has been isolated. A unique aspect is shown by the use of an N or A in a row by itself. Such occurrences have been bracketed. Thus the only unique aspects found are:

single lump sum tender on a fully documented project for variables 3, 4, 11, 13, 14 and 15
provisional or partial quantities for variable 4
cost-reimbursement for variable 5
package deal for variable 11
construction management method 1 for variable 8
project management for variable 10

Of the procurement methods that have distinctive characteristics, the single lump sum tender seldom occurs in practice because projects are seldom fully documented without the inclusion of provisional or prime cost sums. However, it is distinctly different on six characteristics and thus is moderately distinct. The other procurement methods are distinctly different in one other aspect, even if the remainder of the eighteen relevant aspects do not discriminate. Because the remainder of the variables can have any values on any procurement method it is impossible to compare the effectiveness of each procurement method.

Table A1. Comparison of procurement methods in their use of particular facets.

Variable	Procurement method: A single lump sum on a fully documented project	Provisional or partial quantities	Cost-reimbursement	Package deal	Construction management method 1	Project management
Use of competitive tender for construction	M	M	M	M	M	M
Use of select tenderers	M	M	M	M	M	M
Use of provisional and prime cost sums as part of the contract	(N)	M	M	M	M	M
Use of unit prices (bill rates) as part of the contract	(N)	(A)	M	M	M	M
Use of cost-reimbursement for all of the contract	N	N	(A)	M	M	M
Make contract totally firm price	M	N	N	M	N	N
Provision for adjusting total cost on basis of escalation in labour and/or materials	M	M	M	M	M	M
Use a consultant construction manager to advise design team	M	M	M	M	(A)	M
Use a construction manager to co-ordinate the construction phase	M	M	M	M	M	M

Table A1 (*continued*)

Variable	Procurement method					
	A single lump sum on a fully documented project	Provisional or partial quantities	Cost-reimbursement	Package deal	Construction management method 1	Project management
Use a consultant project manager responsible for co-ordinating both design and construction	M	M	M	M	M	(A)
The contractor responsible for design and construction	(N)	M	M	(A)	M	M
Employ a contractor to advise the design team	M	M	M	M	M	M
Overlap design and construction	(N)	M	M	M	M	M
Use multiple prime contractors	(N)	M	M	M	M	M
Stage the letting of contracts	(N)	M	M	M	M	M
Compensate the contractor for inclement weather	M	M	M	M	M	M
Compensate the contractor for industrial disputes	M	M	M	M	M	M
Use time incentives or penalties	M	M	M	M	M	M

(Key: N = never occurs; A = always occurs; M = may occur.)
Note: A unique quality is shown by N or A occurring by itself in a row. These are shown in brackets.

Conclusion. Of the six procurement methods described, all except the single lump sum tender have only one distinctive characteristic out of eighteen variables. The single lump sum tender has six distinct characteristics. Hence, it is concluded that the six procurement methods do not fully indicate what is occurring in the management of a project and it is impossible to make formal comparisons of the effectiveness of the procurement methods.

Appendix B

Definitions.

Allocation of responsibility for the whole process to the contractor: overall responsibility for both design and construction allocated to the contractor.

Architectural quality: the extent to which the building fulfills its intended use. Architectural quality will be assessed by experienced architectural practitioners guided only by their interpretion of the definition.

Building cost: the cost of the building as constructed, based on the value of the contract or contracts plus any adjustments for variations to the contract(s). It does not include the cost of site excavation in order to achieve uniformity. For the purpose of comparison, this cost has been adjusted to that applying at a common time.

Competition at tender: the process by which the tenders from at least two contractors are formally compared in order to select the contractor for the proposed work. In this study it is assumed that price is the basis of the comparison but other criteria could be used.

Complexity of form of construction: the degree of familiarity with the technology used in construction of normal operatives. Complex forms of construction will be unfamiliar to normal operatives or require the use of an unusually numerous set of steps for which special operatives have to be used.

Construction co-ordination: the integration of the activities of the separate individuals, the amendment of the activities of individuals to suit those of others and the ready communication of information between individuals engaged on the project during the construction phase.

Construction planning during design: consideration of the methods and processes of erecting the building as part of the design process with the purpose of achieving a form of construction which can be erected in as efficient a sequence of activities as possible.

Construction time: in this study this covers the time from first pouring footings for the building, excluding general excavation, to practical completion.

Design-construction interface co-ordination: the ready communication of information between individuals engaged on the project at the interface of design and construction, and the organization of the construction process to especially suit the particular design.

Extensions of time through industrial disputes: as title.

Generation of alternative designs: the extent of systematic comparison of alternative designs that are likely to satisfy design objectives.

Number of site managerial personnel: the equivalent number of permanent supervisory staff or managerial staff employed permanently on site.

Quality control on site: the extent to which it is ensured that details documented by the design team are satisfactorily constructed on site.

Time overlap of design and construction: the percentage of the documents not completed when construction commences. A direct measure of this is the proportion of the total fee paid for design that will be earned by the architect after the time of commencement of construction.

Use of a construction manager: a consultant or contractor who is engaged to assist the design team with specialist advice on the construction process by providing time control, by the selection of suitable tenderers and by the co-ordination of the construction phase.

Use of cost monitoring during design: the use of techniques to ensure that the cost of the building remains within the budget figures.

Use of more-competent-than-average construction management personnel: the degree of ability and experience of construction management personnel.

Use of more-competent-than-average design team members: the degree of ability and experience of design personnel.

Use of nominated sub-contractors: the number of sub-contractors nominated or selected by the architect or proprietor.

Use of a project manager: a consultant with overall responsibility for design and construction who does not take any specialist role himself, such as design or construction management.

Use of provisional or partial quantities: the extent of the items described in a bill as provisional thus requiring remeasurement after the work is completed.

Use of select tendering: the restriction of potential tenderers who may engage in competition at tender to those who are considered suitable for the work.

Use of a single co-ordinator: a person responsible for the whole building process including design and construction. It could be a project manager or a person nominated in a design–construction organization.

Use of time control: the use of techniques to ensure that the construction process will be completed in the required time.

Variations to the contract: the net sum of the variations to the contract price as a proportion of the building cost. (Units: cost of variations in $1 million; CVPC in cost of variations).

Measurement of variables

Allocation of responsibility for the whole process to the contractor: measured as whether or not this occurred.

Architectural quality (QUALITY): because the measurement of this is both complex and to some extent subjective, the variable was measured by asking three architectural practitioners to rank the buildings and then adding these rankings to form an interval score. The only guidance provided to the practitioners is the definition of 'contribution to architectural merit for its intended purpose'. (Units: constructed score)

Building cost (COST): the sum of the progress payments made to the contractor or contractors indexed to June 1979 values by the use of the Building Economist Index (AIQS, 1981). (Units: $1 million Australian; COST per square metre: $1 million per 10 000 m^2)

Competition at tender: while the number of contractors tendering for the work, the buoyancy of the industry, the proportion of the bill under competition and the closeness of the bids all appear to be relevant to this variable, due to the use of cover prices and due to the fact that low prices are sometimes submitted by incompetent contractors, it was considered impossible to measure this variable.

Complexity of form of construction (COMPINDX): measured using the questionnaire. (Units: constructed score)

Construction co-ordination (CONCOORD): measured using the questionnaire. (Units: constructed score)

Construction planning during design (CPDD): measured using the questionnaire. (Units: constructed score)

Construction time (TIME): measured in days, excluding days on which no work was done, such as Sundays and public holidays, however days on which strikes occurred were included (TIME per square metre: days to construct 10 000 m^2).

Design–construction interface co-ordination (DCOORD2): measured using the questionnaire. (Units: constructed score – also for DESCOORD)

Extensions of time through industrial disputes (DISPUTDA): measured as the number of days of extension of time through industrial disputes as a proportion of the building cost. (Units: days; DIPT in days/$COST^{0.47}$)

Generation of alternative design (GAD): measured using the questionnaire. (Units: constructed score)

Number of site management personnel: the number of site managerial staff should bear some relationship to the size of the project. As final cost appears to be the best indicator of project size (Bromilow, 1969), and as cost is indexed with regard to time at a value of $C^{0.47}$, it would appear that the indicator of size of $C^{0.47}$ is not unreasonable. Hence projects are ranked by the expression:

$$\text{The number of site managerial staff}/C^{0.47}$$

Quality control on site (SITE QC): measured by the architect's judgement of the contractor on a seven point scale. (Units: constructed score)

Time overlap of design and construction: measured in two ways: (a) the proportion of the total fee paid for design that is earned by the architect after commencement of construction (direct measure); (b) the judgement of the team leader of the amount of documentation completed when construction was commenced.

Use of a construction manager: measured as whether or not a construction manager was used.

Use of cost monitoring during design: measured as whether or not a full cost monitoring service was provided. (In retrospect this variable probably deserved better measuring.)

Use of more-competent-than-average construction management personnel: not measured because of the ill-will this would have caused.

Use of more-competent-than-average design team members: not measured because of the ill-will this would have created.

Use of nominated sub-contractors (NOMSCONT): the actual number of nominated sub-contractors.

Use of a project manager: measured as whether or not a project manager was used.

Use of provisional or partial quantities: measured as the value of work specified by provisional quantities as a proportion of the building cost.

Use of select tendering: measured as whether or not the selected tendering occurred.

Table B1. Measures used in partial correlation and multiple regression runs; missing values occurred through inadequate records.

	Case Number												
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
COST[a]	27	34	41	43	54	62	62	67	70	73	94	97	106
TIME	435	329	564	446	329	414	425	618	360	414	534	983	876
NOSTORY[a]	16	15	14	16	20	17	16	19	21	19	18	17	21
NOLIFT	3	3	3	3	4	3	3	3	4	4	5	4	4
AREA	45	63	84	92	103	122	99	80	167	139	216	147	158
COMPINDX[b]	10	15	14	9	12	9	11	14	13	14	8	14	14
DCOORD1	0	2	0	2	2	2	0	2	2	2	2	0	2
DCOORD2[b]	8	16	4	8	16	8	9	8	16	20	8	4	10
CPDD[b]	8	23	13	7	22	13	11	12	19	20	16	1	2
CONTVAR[a]	—	—	—	—	—	8	8	12	—	—	7	—	6
DISPUTDA[b]	—	—	74	—	—	67	53	114	—	—	87	110	117
QUALITY	25	46	34	27	—	37	59	44	20	28	25	30	44
GAD[b]	29	35	25	24	29	24	38	37	35	23	24	23	38
INPSM	52	50	40	57	37	58	71	64	37	51	56	46	49
NOMSCONT	3	3	3	4	4	4	3	5	3	3	4	6	2
DESCOORD	30	22	26	27	26	27	28	28	22	27	28	24	24
CONCOORD	8	5	4	7	7	7	7	7	5	7	7	7	8

	Case Number											
Variable	14	15	16	17	18	19	20	21	22	23	24	25
COST[a]	124	136	137	150	153	162	163	213	258	266	375	868
TIME	846	846	547	1506	1236	450	997	1276	1122	1105	1128	1269
NOSTORY[a]	26	31	30	32	19	29	28	40	38	39	18	70
NOLIFT	6	9	6	8	6	8	10	10	12	13	8	30
AREA	256	347	425	264	294	474	451	428	543	498	606	1210
COMPINDX[b]	19	10	8	17	19	15	18	15	—	—	20	30
DCOORD1	1	3	3	1	2	2	1	1	—	—	2	3
DCOORD2[b]	11	13	18	11	8	19	11	11	—	—	11	18
CPDD[b]	10	13	27	10	7	26	10	0	—	—	14	27
CONTVAR[a]	6	—	1	13	11	—	—	—	36	—	30	128
DISPUTDA[b]	101	—	—	231	124	95	129	179	—	88	148	150
QUALITY	28	13	35	44	35	45	16	8	—	—	37	52
GAD[b]	29	24	35	42	24	35	38	21	—	—	38	37
INPSM	44	39	35	48	48	35	47	53	56	—	83	65
NOMSCONT	5	4	3	4	4	5	4	4	5	5	6	3
DESCOORD	25	25	27	24	27	29	17	36	—	—	25	33
CONCOORD	6	8	7	7	7	7	7	4	—	—	8	7

[a] COST and CONTVAR are expressed in \$100 000 and converted in the computer program to \$1 million. NOSTORY is the actual number of storeys and converted to (actual number of storeys)/5. AREA is expressed in 100 m^2 and converted to 10 000 m^2.

[b] The ranges of values of managerial actions are: COMPINDX - 8 to 30; CPDD - 0 to 27; CVPC (7 to 150)/1000; DCOORD2 - 4 to 20; DIPT - 18 to 65; GAD - 21 to 42; Total - 1000.

Use of a single co-ordinator: measured as whether or not a single co-ordinator, with full authority for the project for its full duration, as in a package deal or project management arrangement, was used.

Use of time control: measured simply as whether or not a network was used to control construction.

Variations to the contract (CONTVAR): measured according to Bromilow (1970) and arising from:

(a) Variations to builder's work by both addition and deduction. It seems unreasonable to take the net value of these because both can be disruptive to the progress of the work, and the use of net values for a project in which the additions equal the deductions does not show as any variation. This is quite misleading if attempting to measure the disruptive effect of variations. However, while correct in principle, measurement difficulties forced variations to be measured as net figures, that is as the algebraic sum.

(b) Variations to provisional and partial quantity sums by both addition and deduction, but such changes do not involve much disruption to site operations. Consequently, the algebraic sum of these was taken.

(c) Variations caused by rise and fall adjustments are variations to price and not work and were therefore excluded.

Variables values

The full list of variable measures that were used in the partial correlations and multiple regressions are shown in Table B1.

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