COMPARISON BETWEEN PLANNED AND ACTUAL DURATIONS IN MEDIUM - SIZED BUILDING PROJECTS

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The paper presents current findings from research which is investigating project overruns in a sample of 52 building contracts let by a single client in the North East of England. The delays have been identified as *culpable* (for which no extensions of time were granted), *excusable* (where extensions have been given) and those extended times which were specifically due to variations and therefore could not have been reasonably included in the initial target. Data gathered from the projects includes the value, type and location of each project, the original planned times, delays, extensions of time, and other contractual provisions. From the literature available six models for predicting construction times were identified, of which five were considered further. The client's own original predictions were included with those generated by the theoretical models and these have been compared with actual outcomes and with one another. The aim of this part of the study is to examine the relative accuracy of different prediction models when compared with actual times.

Keywords: Planning, prediction, project durations.

INTRODUCTION

Time is an important issue in all construction contracts (Palmer, *et aI*, 1996, p. 202) and completion within time is one of the major measures of success (British Property Federation, p.3). It is in the owners interest to set a reasonable time for completion of the work and provision for this is made in all model forms (Carty, 1995, pp. 323, 324), most of which also require the contractor to prepare and submit a programme. Delays can produce differing contractual responses (depending upon where responsibility lies) ranging from an extension of time to the deduction of liquidated damages (Scott, 1993, pp. 352, 361).

Timely completion is a consistent objective of both clients and contractors. Despite this, it appears to be common for actual durations to exceed what was planned; for example, 80 % of the projects investigated by Bresnen *et al* (1987) finished late. On the face of it, this failing could lie in poor performance, poor initial prediction or both.

Certain theoretical models exist for predicting construction durations but information about their efficacy is limited (Nkado, 1995, pp. 81 -87). The purpose of this study was to select several such models from the literature and use them to generate predictions for real projects; these theoretical predictions, together with the original planned duration could then be compared with their actual durations.

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FACTORS WHICH AFFECT CONSTRUCTION DURATIONS

There are many factors which have been held to affect construction durations (see for example Kaka et aI, 1991, p. 382; Bromilow, 1980, p. 79; Nkado, 1992, p. 392; Kumaraswamy et aI, 1995, p. 81; Chan et aI, 1995, p. 209).

For building projects, cost and floor area are the most frequently considered. Other factors include buildability;, management issues, such as site productivity, variations to design, weather conditions, the number of storeys, the location and type of contract and client type and experience. Consideration of these and other factors has led to the development of various models for predicting construction durations. The following five are broadly representative.

FIVE MODELS FOR PREDICTING CONSTRUCTION DURATIONS

Using various combinations of the factors listed above, the following five models are amongst those which have been developed for predicting construction durations.

1. Time- cost relationships
In 1969, the C.S.I.R.O., the division of Building Research Melbourne, carried out investigations into the construction time performance. These were later published by Bromilow in an examination of the relationship between cost and time (Bromilow, 1980). In Following this Kaka *et aI*, (1991) applied a cost/time predictor to a study of UK construction projects. The relationships take the form:

$T=K \times C^B$

or

$\text{Log } T = \text{Log } K + B \text{ Log } C$

Where T is the construction duration in days

C is the project cost

K is a constant describing the general level of construction speed

B is a constant indicating the effect of cost on time performance

Table 1 shows Bromilow's K and B values

Table 1: K and B values

Group of Building	K	B
Total public fixed price	398.8	3176
Public indexed price	486.7	2050
Private fixed price	274.4	.2120
Private indexed price	491.22	.0871
civil indexed price	436.3	.04370
civil fixed price	258.1	.4693

Having taken into account the type of client, project, tender, competition, and form of Contract[3] it was found that project durations were as predicted unless there were significant

[3] For example, adjusted price contracts took longer than fixed price contracts design variations. However, since variations cause both delay and increased costs the i' cost/time relationship remains relatively constant.

2. Time / floor area relationships

A pilot study in Hong Kong has demonstrated a possible relationships between time and floor area (Kumaraswamy, *et ai*, 1995, pp. 82 -85) it is in the form :

$$T = L \times A^M$$

Where T is the construction duration in days

A Is the total gross floor area in m^2

L and M are constants whose values are shown in Table 2 (below)

Table 2: Land M values for buildings for public clients

Type of Building	L	M
Total public buildings	89.8	.203
Public housing	74.8	.214
Other public buildings	51.6	.268

3. Time / number of storeys relationship

The number of storeys has appeared as another factor affecting the duration of a project (Chan, *et al*, 1995, pp. 210, 211), for example in the form:

$$T = F \times S^G$$

Where T is the construction duration in days.

S is the number of storeys of a building.

F and G are constants whose values are shown in Table 3 (below)

Table 3 : F and G values

Type of Building	F	G
Total public Buildings	405.8	.222
Other public Buildings	405.8	.222

The test results of applying this formula show that the duration of a building's construction can have a reasonable direct relationship with the number of storeys of a building project though this is not as strong as its relationships with cost, and commonsense suggests that the relationship is more applicable to certain building types and construction processes.

4. Multiple regression on time-related variables

Consideration of the above led Kumaraswamy *et al* (1995, pp. 82 -85) to apply multiple regression on cost and area to develop a predictive equation for construction duration. The model was proposed to be:

$T = K \times C^B \times A^M$

Where T is the construction duration in days.

K is a constant describing the general level of time performance
C is the project cost

A is the total gross floor area in m2.

B and M are constants indicating the effect of cost / time and floor are / time effects (respectively).and their values are shown in Table 4 (below)

Table 4 : K, Band M values

Group of Building	K	B	Group of building	M
Total public fixed price	398.8	3176	Total public buildings	.203
Public indexed price	486.7	2050	Public housing	.214
Private fixed price	274.4	.2120	Other public buildings	.268
Private indexed price	491.22	.0871		
civil indexed price	436.3	.04370		
civil fixed price	258.1	.4693		

5. Construction time planning dials

A study by the national Economic development office (NEDC For Construction, 1988, pp. 45 -50) indicates a positive relationship between construction time and cost and the study offers an aid to assess the construction time in the form of *construction time planning dials*. In order to use these dials some basic information about the project is required, namely:

the total estimated project cost;

the end use of the building (whether office retail or other);

whether purpose -built or speculative;

whether new, extension or refurbishment.

The predicted construction durations of specified projects are shown on pre-calibrated circular scales in relation to their cost. A clock -type centre pivoted hand is used to help dial the appropriate predicted project time. A choice of two values of such times are provided -for average or for good performance.

RESEARCH STRATEGY AND DATA COLLECTION

Data were obtained from a large public client in the North-east of England. The files of 58 refurbishment projects completed in the period between 1987 and 1995 were examined, of which 52 were sufficiently detailed for the purposes of the research. The projects were medium-sized (£500,000-£2,000,000) and the majority were contracted under the JCT Intermediate Form of Building Contract (Joint Contracts Tribunal, 1984).

The projects were classified by the client into five groups according to the nature and scope of works. These *groups* are shown in Table 5.

Table 5 : Projects shown by group

Group	Description	Number
A	external fabric overhaul	20
P	re-roofing	9
S	solid floor replacement	5
T	window/door replacement	3
W	housing modernisation	15

This classification permitted subsequent analyses to be conducted both in terms of total projects and by individual group.

The purpose of this study was firstly to compare the planning of construction durations with, the actual results, and secondly to compare the effectiveness of different planning approaches. Each project had an original planned duration, that is, the duration stipulated or agreed when , the contract was entered into. This was set by the client team using (as yet) undefined methods. These methods will be the subject of scrutiny later in the research project but are outside the scope of this paper.

Hypothetically, different planned durations would have resulted from the use of any of the various models described in the previous section (Models 1-6). As all of these models are based upon project characteristics which were reasonably accessible for the 52 projects under survey, hypothetical results can be generated using each model with each project. The study compares these hypothetical results with both the original and the actual durations.

The concept of actual duration is not a straightforward one. An acceptable starting point would be to calculate a project's duration contractually, that is, using the date of Practical Completion. This is an attractive proposition since the date would normally be recorded in a certificate, and would include both culpable delays (for which, no doubt, damages would be available) and excusable delays (for which an extension of time should have been given). However one of the main causes of extension of time is variations (Bromilow, 1980 p. 80). These, by definition, alter the extent of the project and it would therefore be wrong to include such extensions in the comparison. Fortunately the project data enabled the calculation of a net actual duration that is, a duration calculated using the date of Practical Completion but from which all extensions of time due to variations have been deducted.

To summarise, the following were calculated for each project:

(1) a *planned duration* which was stipulated or agreed when the contract was formed;

(2) an .*actual duration* calculated using the date of Practical Completion and thus including both culpable delays and extensions of time;

(3) an *extended duration* (including the extensions of time but not the culpable delays;

(4) a *net actual duration* from which all extensions of time due to variations had been deducted.

Note that although constructs (2) and (3) are useful for other research questions, only the planned duration (1) and net actual duration (4) are appropriate to the present work. Thus the planned duration and other hypothetical planned durations can be meaningfully compared with the net actual duration.

RESULTS ANALYSIS AND DISCUSSION

Hypothetical durations for the 52 projects were calculated using the five models. A sixth result (ie the original *planned duration)* was added. Table 6 shows the results of the exercise for the first ten projects only.

Table 6 : Sample of results (planned and actual)

	Name of project	P	1	2	3	4	5	N
1	Newbiggin Hall 1	16	30	63	79	14	26	21
2	Newbiggin Hall 2	12	22	51	79	11	24	12
3	Newbiggin Hall 3	12	31	63	79	15	29	14
4	Benwell Dwellings	23	45	59	79	15	30	27
5	Blakelaw Sports Hall	30	49	73	68	22	47	31
6	Blakelaw School	30	49	47	58	21	48	33
7	Mill House	55	46				47	55
8	Vale House	52	49	47	68	21	57	50
9	Shieldfield House	41	48	73	68	22	49	40
10	Denton Bar House	86	60	80	68	27	60	97

P = the client's original planned duration

1 = Hypothetical planned duration using Model 1

2 = Hypothetical planned duration using Model 2

3 = Hypothetical planned duration using Model 3

4 = Hypothetical planned duration using Model 4

5 = Hypothetical planned duration using Model 5

N = Net actual duration (see above)

The next stage involved determining which of the six planned durations most closely approached the *net actual durations.* Various tests were applied; results given below are restricted to those obtained by calculation of correlation coefficients, using the SPSS statistical programme.

The correlation coefficient has a range between 0 and 1, the highest value giving the best results. The results of using this method for all projects are shown in Table 7.

Table 7 : Correlation of planned with actual durations (all projects)

Model	Details	coefficient	ranking
Planned	Estimated by client	.9496	1
Model 1	$T = K \times C^B$	.8489	4
Model 2	$T = L \times A^M$	.7602	5
Model 3	$T = F \times S^G$	.0585	6

Model 4	$T = K \times C^B \times A^M$	.8890	2
Model 5	By using dial	.8836	3

For all projects the correlation is highest for Model 4 (.889) followed by Model 5 (.8836), but both of them gave inferior results to the client's own planned duration (.9496). When the different types of project were examined in isolation, the results were similar, except that in Group W, the original planned duration was second best to Model 5. A breakdown of rankings by project group is shown in Table 8.

Table 8 : Correlation of planned with actual durations (by individual groups of projects)

Model	**Rankings**				
	A	**P**	**S**	**T**	**W**
Planned	1	1	1	1	2
Model 1	3	2	2	5	5
Model 2	5	5	4	2	3
Model 3	6	6	6	6	6
Model 4	2	4	3	3	4
Model 5	4	3	5	4	1

The results for all projects suggest that the planning methods adopted by the client are superior to the theoretical models examined, of which the model using multiple regression on cost and area (Model 4) is generally the next most effective.

Of the individual project types, only in the case of housing modernisations (Type W) did a theoretical model out-perform the planning of the client team. This was Model 5 which involved the use of construction time planning dials produced by the national Economic development office (NEDO, 1988).

The planning of durations by the client team is evidently a fairly accurate method of estimation, once project variations have been discounted.

Towards a superior model

Once project variations have been discounted, the planning of durations by the client team (the planned method) is evidently superior to the results obtained from the basic theoretical models. This, however does not preclude room for improvement. An attempt was next made to explore how adjusting the basic theoretical models could improve their predictive qualities. On further examination, the planned method shows most success for projects with shorter durations: there are ranges of larger projects for which the planned duration is much less successful. Initial attempts to manipulate the basic predictor models have suggested that improved results are possible over these ranges, particularly for certain project types. A minority of projects have proved to be extremely difficult to predict with any method.

Conclusions and further research

The accuracy of durations obtained from some basic theoretical models have been compared with actual results. The predictions have initially proved to be inferior to those planned by the client team. However it appears possible to improve upon their accuracy, especially with larger projects.

Amended models, when applied to the original project data have shown an improvement, not only on their predecessors but also on the client's planned durations.

The next stage in the research will be to develop the models and to test them with new data. It is hoped that the research will yield some useful conclusions about methods of predicting durations for the various project types and sizes which the client encounters. This may have implications for the client's future behaviour, both in establishing contract periods, and in risk attitudes towards contractual provisions for delays.

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