THE UNIVERSITY OF ASTON IN BIRMINGHAM

DEPARTMENT OF CONSTRUCTION AND

ENVIRONMENTAL HEALTH

A CRITICAL STUDY OF PROJECT TEAM ORGANISATIONAL FORMS WITHIN THE BUILDING PROCESS

Thesis submitted for the

Degree of Doctor of Philosophy

by

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April 1982

SUMMARY

This research explores the variations in organisation of a building team when undertaking a building project. It examines those variables thought to be present in the building process which influence the performance of the building team, and the outcome of the building project.
The main hypothesis proposed is:-

> 'when the building team and project procedures are appropriate to client and project characteristics, higher levels of success will be attained'.

A model is developed to illustrate the relationships between variables in the building process, and to assist in the selection of a building team and project procedures appropriate to a particular building project.

The results from 32 case studies are then analysed to explore the relationships given in the model, and to test the hypotheses. The results suggest that, depending on the circumstances, some building teams and project procedures are more likely to provide a successful outcome to a project than others. In particular the level of managerial control is important. However no particular organisational form is better than another, per se, rather it is the combined effect of a number of variables which influence the success of a project.

KEYWORDS:- Building process, organisational forms, building team.

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DEFINITION OF TERMS

The term ' building process ' signifies the total process from the point at which the client decides that he wishes to build, through the design and build phases to completion.

The ' building team ' describes those members drawn from the staff of professional practices and companies in the industry who are brought together to design and build a project.

The term ' organisational form ' (or project team organisational form), refers to the way in which all the variables of client and project characteristics, building team and project procedures are related together during the execution of a project.

The term ' traditional team ' refers to the traditional organisation of the building team where members belong to autonomous professional practices and construction firms, and join together for the duration of the project only.

The term ' integrated team ' describes situations where some members of the building team are associated in a composite practice.

The term ' design and construct ' refers to the situation where one firm offers a complete and comprehensive service to the client, embracing design, documentation, etc., through to construction.

INTRODUCTION

The construction industry is essentially a service industry. It combines the skills of the planner and designer, and of material and component producers, with the efforts of the builder to provide buildings for the community. Not only is the industry very large, it is also characteristically diversified and heterogeneous. A significant feature of the industry is its fragmented nature and the dichotomy which exists between the design and production functions. The various processes that are involved in providing a building are generally managed by a team of people brought together for that one project and disbanded thereafter. This team usually comprises individuals from various professional and specialist firms who are responsible to the client for the design, management and construction of the building project.

The fragmentation and complexity of the industry, and the ephemeral nature of its projects, place great dependence on the competence of the building team in setting up the building process and bringing the work to a successful completion.

Concern has been expressed for many years about the organisation and effectiveness of the building team. As long ago as 1964, Banwell said 'it is clear to us that existing contractual and professional conventions designed in, and for, other days do not allow the flexibility which is essential to an industry in the process of modernisation and will have to be reviewed'. In a study on communication within the industry (Higgin and Jessop, 1965) concluded that 'the pattern of relationships and divisions of responsibility in any building team have much more effect on the way communications function than have any particular aspects of the techniques of communication themselves'. Both these studies directed attention to the manner in which the building team is organised. It was postulated that this might be a key element in the operating efficiency of the industry. Since that time the British economy, and the construction industry, have suffered substantial changes, while later studies did not demonstrate a corresponding change in the organisation of the industry. Wood (1975) for example shows that the vast majority of public contracts are still let by traditional methods, and Wilson (1975) found the same to be true for the private sector.

Critics of the traditional approach point to the possibility of conflicting interests in the building team, maintaining that internal conflict acts against the client's interest. Nevertheless some different groupings of members of the building team have come into being. Different groupings have centred upon modified contractual arrangements or organisational forms. They tend to seek an organisation which might harmonise and integrate the team.

The principal arguments for integration are:-

1. Changes in technology, in procedures, in materials and in the sheer complexity of modern building require greater interaction than the sequential completion of contributions of traditional procedures in order to provide an efficient service.

2. The separate and often isolationist education and work experience of the members of the team creates problems of communication and co-ordination.
3. Integration need not diminish the independence of the professional who would still operate under professional status, ethics and codes of conduct.

The traditional approach on the other hand concentrates on the link between the professionals and the client, emphasising the importance of this relationship and claiming that it provides the best possible advice and service to the client. The arguments in support of this approach emphasise:-

1. The role of the professional body. This ensures professional competence, educational standards and codes of conduct, all of which are seen to be in the client's interest.
2. That the most effective building team may be that put together for each project in recognition of the client's needs. This arrangement provides flexibility.
3. That the professional has access to specialist knowledge and experience which is generated and transmitted within the professional circle. He has the advantage of working with other professionals, benefitting from contact with a wide range of experience and knowledge.
4. The traditional approach is based on the fragmentation of the industry and this provides a flexibility which is designed to cope with the uncertainty and fluctuations of the construction market.

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Where there is dissatisfaction with the service provided by the industry it may arise from problems associated with the nature of the building product, the performance of the building product, the effectiveness of the production/delivery process, or the price demanded of the client for the product. Suggestions which have been made to ameliorate the problems of organising and controlling design and production in the construction industry fall into four categories, either to:-

1. Put design and construction under one commercial umbrella. In other words concentrate responsibility and accountability.
2. Change procedures so that construction expertise is available to the designer at the design stage of the project, contractual accountability being restricted to the construction process.
3. Introduce an independent professional co-ordinator for the project, concentrating control.
4. Increase involvement of the designer in the construction phase.

Some members of the industry and some clients have tailored the systems to suit particular situations. Examples are the adoption of serial contracts and other experiments by some local authorities, described by Carter (1968), Bailey (1973), individual client - contractor relationships such as that between Marks and Spencer Ltd. and Bovis Ltd., reported by the then Ministry of Public Buildings and Works (MPBW 1970), and the adoption of the design and construct system by public corporations reported by Cameron and Pearson (1973).

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A number of researchers have investigated the characteristics, advantages and disadvantages of this wide range of organisational forms, for example, Crease (1971), Turin (1972), Hulse (1972), and Harris (1973). The industry has also responded to the increased use of these alternative forms by conducting investigations and publishing guidelines for members of the industry and clients, see:- The Ministry of Public Buildings and Works (1966), The Royal Institution of Chartered Surveyors (1973), The National Economic Development Office (under Wood 1975 and Wilson 1975), the Agua Group (1975), Stokes (1978), and Graves (1978).

White (1978) sugggests that a building process consultant is needed to advise the client on the choice of the form appropriate to the client's individual needs. He would be a professional with knowledge and experience of a wide range of organisational forms who could analyse the client's needs and select, or assemble, an organisational form which would give the best results for that client. However there is no body of objective information on which to base such a service, and subjective advice in such a complex field would seem to be an inadequate basis.

This research pursues this point and aims to clarify the relative merits of these different organisational forms with a view to providing some indication of how they may be matched to particular circumstances. It has proved to be an extremely complex task. Controlled comparisons are needed, but because of the nature of the industry and the number of variables involved, it is often impossible to isolate the variables of interest from the interactive effect of other variables. The evidence available relating to the efficiency of the organisation of the construction industry tends to be limited to a variety of studies of different projects and organisational forms. Some are more detailed than others but all suffer from the problems of the sample size and number of variables.

Previous research has been largely fragmented, and, though it has examined certain areas, it has not examined the problem as a whole. This research adopts the holistic approach, seeking to examine the entire building process, and to indicate the relationships and dependencies within it. Some researchers have attempted this, notably Turin (1972), Morris (1972), Cakin (1976) and Boland (1978).

At the centre of the building process is the building team which supplies all the design, managerial, and constructional skill necessary to realise a building project. The objective of this research is, therefore, to examine the function of the building team, and the various forms in which it may be organised, and to assess the merits of these forms. As a vehicle for this examination a model has been developed which attempts to show the relationships between the variables present in the building process. The objective of the model is that it might be used to select an organisational form which best suits a particular client and project.

Introduction

The principal hypotheses which the research seeks to test is:-

'when the building team and project procedures are appropriate to client and project characteristics, higher levels of success will be attained'.

The objective of the research is:-

'To develop a model to assist in the selection of the building team and project procedures appropriate to client and project characteristics which will result in project success.'

CHAPTER 1 - VARIABLES IN THE BUILDING PROCESS

This chapter seeks to identify and discuss the principal variables which are present in the building process, and which are thought to be most relevant to the performance of the building team and the outcome of the project. These variables are discussed under the following six main headings, with a number of subvariables described under each heading (The measures used for each of these variable are given in chapter 3):-

1.1 CLIENT CHARACTERISTICS

The client is assumed to be the sponsor and initiator of the building process, and it is anticipated that different client characteristics will influence the building process and the resulting success of the project. This variable is intended to distinguish between, for example, a public client funded by central or local government, and repeatedly needing buildings for purposes such as health, education, transport, administration and housing; and a private client, using private funds and having a more sporadic need for industrial or commercial buildings. It is relevant to note that, in some cases, the building provided for the private client may be considered as a factor of production. A pulp mill recently constructed in Cumbria, for example, had a building costing £10m, housing machinery which cost £70m. The private client's priorities may thus be different to those of a public client. The lowest tender price may not represent the greatest assurance of delivery or the optimum building for the purpose.

Clients with previous experience of building should be familiar with the building process. They may have their own team of experts, depending on the scale of their activities, and may be considered 'sophisticated' clients. One would expect such clients to achieve a higher success rate, and more readily achieve satisfaction, than inexperienced clients.

Closely linked with the idea of sophistication is the concept of 'specialisation' which is intended to account for the client who has a repeat need for a particular type of building and may therefore develop a highly specialised knowledge and expertise. Under these circumstances it would be reasonable to expect that many snags would be anticipated and thus that later projects would run smoothly.

Further elements of a client's characteristics, which might colour his approach to building and influence his part in the process, are the procedures exercised for funding, approvals, monitoring progress etc. In some cases these may be quite involved and time consuming and, indeed, may give rise to delays. The degree of personal involvement of the client in the building process must exercise an effect on the organisation and working relationships of the building team. Also important are the client's priorities and expectations on cost and time. An overiding need for low cost or fast construction time could conceivably influence many aspects of the building process.

1.2 PROJECT CHARACTERISTICS

A building project may have characteristics which incline it towards a particular organisational form. For example large capital projects will obviously need a different type of project organisation to that of relatively low cost projects. Size has been established by many studies as a major variable in the performance of organisations and is likely to influence the organisational form in building projects. One might also expect large complex projects to take longer to design and longer to build.

A highly complex project may require a building team which can provide a wide range of service and expertise. A relatively uncomplicated project, regardless of monetary value, should, in theory, require a simpler organisational form. The concept of complexity has been discussed by Miller and Rice (1967), Morris (1972), Turin (1972) and more recently by Bennett and Fine (1977).

Variables in the building process
Project characteristics

Three aspects are worthy of consideration:-

1. The initial complexity of the problem as posed by the client (the brief).

2. The complexity of the solution to the problem as elaborated by the design team (the design solution).

3. The complexity of the production and assembly operations required to implement the design by the builder (the technology of the building).

Objective measurement of complexity is not easy; some idea of the scale and complexity of the project may be gained by consideration of design time, building time and the ratio of build rate, ie. cost divided by building time. (Design/build overlap is also relevant here).

The cost of a project is an important characteristic which may be determined relatively accurately. As far as possible it should represent the true cost of the project with allowances made for variations, fluctuations, claims etc. Where projects are constructed at different times the figures should be brought to a common base date, to facilitate comparison.

1.3 THE BUILDING TEAM

Each member of the building team contributes a particular expertise and is generally concerned with a discrete functional area in the building process. Teams therefore are, in essence, an association of specialists from different disciplines with inherent problems of co-ordination and communication.

Integration may thus be an important variable in organisations and could afford a measure by which to differentiate between forms. The traditional arrangement of independent professionals working from separate practices and coming together for the duration of a project while retaining their individuality, would be an example of a low level of integration. On the other hand a system where all services, including construction, are provided by one body should afford a high level of integration. Design and construct is an obvious example of this. There will be a wide spectrum of partially integrated arrangements between these two extremes.

It must be noted that the integration is structural or organisational and should not be confused with well co-ordinated, and co-operative, working relationships. These could equally be attained by a traditional team, or any other of the arrangements mentioned.

An examination of the relationships within the building team has been made by Miller and Rice (1967). They examined the building of a new steel works from inception through design and construction to commissioning. They directed their attention particularly to the organisational boundaries and identified the forms and relationships throughout the process. They found that the process of creating a new manufacturing capability (the client operating system) requires two principal activities. First, the design and building of the client organisation that will operate the new manufacturing process, ie the human resources, their roles, responsibilities and relationships, and the material resources, plant design and layout of the production process. Second, there is the design and construction of the building in which the manufacturing process will be carried out.

It must be emphasised at this point that Miller and Rice are discussing the building of a new steel works. It is the kind of project where there is a high degree of interrelation between the physical building and the operating system. This might not be true of a factory on an industrial estate where such buildings are built as an envelope for tenants to install their plant and process. Nor indeed need it be true of a warehouse, or of roads or bridges. For other building types the relationship between the building process and the client operating system will vary. For housing, the relationship between the building and the living pattern of the occupants should be readily appreciated. A hospital or university would be more complex.

Where the relationships between the client's operating system and the building are complex, the quality of these relationships (and hence the organisational form) would seem to be critical to the success of the project.

The case study examined by Miller and Rice is an extreme example of the problems that can occur due to this type of complexity. The company sponsoring the new steel works commissioned the design and construction of a new works. But in parallel they commenced a programme of organisational design to operate the new system. Inevitably, the client's team designing the new organisation made innovations and wanted to change the building design. Such variations during the construction of a project can cause great difficulties for the building team, though it must be said that the ability to cope with such variations provides a degree of flexibility which helps to ensure that the client gets the building he needs. Miller and Rice also discovered, however, that due to problems within the client organisation, there was no guarantee that these innovations were indeed relevant or correct, due, in their view, to the inability of the client to understand and develop his own operating system. This is a very taxing function of the building industry, particularly the designer, - to validate and interpret the brief.

Miller and Rice concluded that part of the problem was the failure of the steel company to create an organic organisation to design the new company organisation structure. This concept has also been examined by Burns and Stalker (1961) who investigated the electronics industry in Scotland. They found that the firms which were structured organically were more able to adapt and change in the dynamic environment of the electronics market. The firms that were found to be organised in the mechanistic manner were less able to cope and were less sucessful.

This idea that organic organisations are flexible and more able to cope with dynamic, fluid situations than mechanistic organisations has been explored within the building industry by Ashridge Management College (1973). The Ashridge research unit studied twenty-five printing firms and twenty-five building firms. The printing firms which were successful conformed to one organisation type, however the research team found the building industry so heterogenous that a range of organisation types, each appropriate for different sectors of the building industry, was suggested.

The initial objective had been to study the application of the Burns and Stalker model to other industries, but the researchers found difficulty in using this model, and developed a more complex model with two principal dimensions of control and integration. They also investigated management style, following a conceptual model used by Blake and Mouton (1964).

Control was defined as the extent to which the activities of members of the management structure are determined by higher authority and subject to close review on the one hand, or are more the result of the exercise of discretion and process of discussion on the other. The dimension of integration (following Lawrence and Lorsch 1967) is the extent to which the activities of members of the management system are closely co-ordinated in relation to overall objectives.

The researchers found that the structural model failed to predict performance sucessfully for the building industry. They formed the view that this was due to the extreme heterogeneity of the industry. Different building firms faced quite different problems depending in their particular part of the market, hence the need for different organisation structures. Their research was centred on the organisation of professional practices and construction companies, whereas this research is concerned with the building team. However their work is of interest because the building team consists of members from such firms, and the building team must operate within the same framework.

The building team can be seen as highly differentiated, facing a considerable problem in its own integration. Lawrence and Lorsch (1967) found that the need for integration was greater when organisations became more specialised and differentiated. This was explored by Morris (1972) in examination of the design/construction interface. Morris found that co-ordination and control at this interface are difficult not so much because of the extent of the differentiation as of its complexity. In his view the traditional system lacks the flexibility to cope with projects of this type, and newer organisational forms, eg. project management, might be more sucessful when projects involve problems of speed or complexity.

This previous work leads us to speculate that it is not the changing roles and relationships within the team that cause the problem. Rather, it is the input, ie. the client and project requirements of speed and complexity, which creates difficulties for the team, unless it has a structure which enables it to cope with this type of problem.

This is contrary to the implications of interesting work by Weisbord (1976). He used Maslow's concepts of high and low synergy in an analysis of medical centres. Weisbord's thesis is that physicians and scientists are socialised to a form of rational, autonomous, specialised behaviour which is the antithesis of the traditional 'all for one and one for all' approach to team activity. Weisbord proposed that, though the tasks in medical centre systems are extremely interdependent, the people do not act as if this is so because they are individuals with their own goals and careers, and do not necessarily depend on the success of the team for their own personal advancement and advantage.

The behaviour of the building team seems to encompass situations of both high and low synergy. One of the advantages argued for some of the newer organisational forms is that they tend to promote integration, co-operation, co-ordination and good communications (high synergy in Maslow's terms).

Sayles and Chandler (1971) provided an interesting corollary to these problems of the building team when they studied the problems of managing large systems based on work at The National Aeronautical and Space Administration (NASA). Such aerospace projects involve the co-ordination of hundreds of designers, scientists, research agencies, engineers and contractors.

The NASA project team was invariably organised on a matrix basis, with a project manager. The design of the project organisation, the contractual arrangements with contractors, and the techniques for integration and management were of extreme importance.

This is true also of the operation of the building team, which is both dynamic and flexible, with highly differentiated professional and social independence of the members of the team. Many difficult and different tasks must be undertaken by the architect and other specialists during the design and construction of a building project. But an architect may be involved in more than one project at a time each at a different stage. Indeed many members of the building team (particularly the professional members) may at one and the same time be members of more than one building team, acting on more than one project. Involvement in more than one building team may not only reduce commitment, but also means that failure of one project will have a reduced impact on the individual member (and his firm) in terms of reputation and career prospects. Where projects are complex, there are clearly difficulties of contact and communication. This must create problems of co-ordination and information.

Some organisational forms may provide situations which encourage and enhance integration, but the independence of the individual team members is still present, so that some of Weisbord's points about goals and careers may be relevant.

1.4 PROJECT PROCEDURES

Methods of tendering

This variable embraces the procedures adopted for selection of the members of the building team, and in particular the constructor. In most cases the professional members of the team are appointed in accordance with professional codes on an agreed scale of charges; however, this need not always be the case and is not the basis used in some other countries. There is also pressure in this country to introduce an element of price competition amongst professionals. The construction team may be appointed by negotiation, on the basis of a fee, or under competition. In some cases the design and construction is done as a complete package and both may, therefore, be let by competition. The selection procedures applied to members of the team are therefore by no means always the same.

The apportionment of risk seems to be the best criterion to use to differentiate between project procedures. In essence the selection and appointment of the members of the team, and the operating procedures they adopt, are based on apportionment of risk and responsibility. The terms of appointment of the construction team depend upon an assessment of risk and return in whatever bargain is struck. Systems such as competitive tendering would involve a high degree of risk, whereas cost reimbursement contracts would be low risk bearing by comparison.

Managerial Control.

The building process relies on effective co-ordination, co-operation and communication. If objectives are to be achieved satisfactorily then an element of managerial control is necessary. This may be evident in a number of different ways.

Certain controls are external to the project and the client, for example codes, regulations and standards. These will mould and limit the design solution derived from the brief. Once the design has evolved, subject to the external controls of the community, the environment, and the wishes of the client, the design team must then produce documentation to communicate it to the construction team. This establishes standards which constitute a basis for the control system.

The documentation may express the objectives in a number of forms:-

1. Drawings establish location, size, shape, orientation, etc of the building and, in some respects, quality.

2. Specification is largely concerned with establishing quality and sometimes performance.

3. The bill of quantities or schedule of rates itemises price.

The formal contract signed by the parties is the legal control, and the documentation is part of that control. However, control is ineffective without monitoring of performance, checking against the standard, and corrective action. Therefore, during construction the design team must ensure adherence to the plans and specification. The above controls are well known and fairly straightforward. There are problems however and one might ask:-

1. if the client is competent to make judgments about the quality of the design solution. The National Board of Swedish Public Building (1971) explored the development of a complex scoring system based on space standards, etc., but value is a complex criterion when applied to buildings.

2. if the initial capital cost of the tender is a reliable guide to value. Specification may be depressed to meet cost limits.

3. if the 'cost in use ' or 'life cycle cost' of the building is likely to be significant. In many cases the cost of maintenance throughout the life of a building and the cost of running the operation is indeed more significant in real terms than the initial capital cost.

4. if the project is being well managed. The delivery and quality of the product is important. The experienced professional can reinforce legal control of the parties (client and contractor usually). Professional experts exercise their judgement and administer the system in the interests of the client, some with more efficiency than others.

The degree of managerial control may therefore be reflected in the range and type of control mechanisms set up for the particular problem. At one end of the range would be a very low control situation, where neither architect, professional design team, drawings, documentation nor standard form of building contract exist. This might be the case for minor works, but it may also arise in more complex and expensive cases where the client feels confident of striking a bargain successfully without aid. The purchase, delivery and erection of a standard building is such a case. A contract exists, but the terms of the contract are such as might be applied to the purchase of consumer goods.

Building projects with the normal range of controls in terms of drawings, bills of quantities, and specifications, may be subject to variation in the amount of detail. The detail of systems adopted for monitoring performance and taking corrective action may also vary. A high control situation would therefore exist if detailed documentation was administered through a system of regular meetings, inspections, and instructions.

1.5 THE INFLUENCE OF THE ENVIRONMENT

The term the 'environment' describes all external influences on the building process. Broadly these may be grouped as social and political; economic; technological; and major change influences, and may act at national or local level, and in different ways in the public and private sector.

Social and Political

Decisions on the priorities of the national building programme will affect the construction market, directly where expenditure cuts or changes in emphasis affect specific projects, and indirectly by influencing the level of demand for materials and other resources. This influence may also occur at local government level and will affect both public and private sectors. Changes in the structure and needs of the community will create a demand for building. Demographic change can alter the need for housing, schools and jobs. Alterations in the structure and tastes of society can influence the type of facilities required. Detailed prediction and analysis of this variable in relation to the building process would prove extremely difficult.

Economic

Public and private building activity is financed from capital reserves or loans, very largely as a form of investment. The availability of funds is regulated by dependable revenue. Thus, in optimistic periods, clients may anticipate a need for constructed facilities. Conversely, periods of recession may adversely affect the need or ability to fund building works. Inflation offers some incentive for capital investment in buildings.

Sugden (1975) explored input-output analysis of sales and purchases by various industries, and showed that most industries purchase construction. Construction therefore serves many parts of the economy, and is vulnerable to overall economic trends. He argues that since each industry only spends about 3 or 4 per cent of its own capital investment on construction, then industry can cut back its construction without apparent harm to itself. Since industry, and therefore the economy, is relatively insensitive to the level of construction activity, it provides the government with a convenient mechanism for regulating the economy. Sugden also points out, however, that the construction industry gets 90 per cent of its raw materials such as bricks, cement, timber, etc., from only 11 industries, and these sell most of their output to construction. Governmental measures to restrict building thus have a limited effect on the economy as a whole, and do not carry over into matters of international finance, the strength of the currency, or the export markets of the country. This vulnerability of the building industry to regulation by government is now entrenched in its folklore.

However, Sugden goes on to analyse fluctuations in demand for all productive industries, and concludes that construction shows a lower coefficient of variation than any other industry. In his view, the theory that construction output suffers unduly from variations in demand is not upheld.

Hillebrandt (1977) offers an explanation for this apparent contradiction; she says that though the industry as a whole does not suffer unduly, particular sectors may be hit by fluctuations. Due to the characteristics of the industry (ie long lead-lag times, long construction times, large value contracts, heterogeneous organisation and markets) individual projects or sectors may be influenced by such fluctuations. However the total picture for the industry may remain fairly constant because there is often time and the opportunity for some firms to move into other markets. Wood (1975) also explores this point of market fluctuations in construction with particular reference to the public sector.

In an analysis of the flexibility of the industry to respond to changes in the level of demand, Stokes (1978) felt that the government should avoid rapid changes in demand for construction. Furthermore, he suggested that the Building and Civil Engineering Economic Development Councils (EDC's) should prepare, in conjunction with government, a regular 5-year assessment of future demand. However the government of the day could hardly be expected to forego the convenience of a means by which to regulate policy in capital investment.

Technological

Materials, techniques, standards, and procedures, all influence the quality and rate of building activity. Shortages of materials hold up production. Events such as the collapse of the Ronan Point tower block, or a dramatic change in energy costs, can halt a particular form of construction while standards and procedures are reviewed. There is an argument therefore for considering the constraints of quality control, cost yardsticks and approval procedures as aspects of the technical environment.

Major change

Perhaps the most important aspect of the environment variable is that of change. Building projects with their complexity and timescale are particularly vulnerable to changes in the environment. The timing of an environmental influence may moderate or enhance its disruptive effect. Withdrawal of funds during the construction period is obviously a severe influence, but a shortage of materials or a change in technology may also affect the programme.

Some members of the team are more susceptible to environmental influences than others. The client may have to alter a programme or introduce a change of direction. Building companies may also have financial problems or resource problems.

An interesting study by Lea, Lansley and Spencer (1974) into the efficiency and growth of 23 building firms, examined the changes in economic demand during the period 1960 to 1970. Though changes in demand affect the level of activity in industry generally, they found that this was not a very important factor in the relative efficiency and growth of the building firms studied. This is explained in three ways. Firstly, firms in the building industry can increase or reduce the size of their labour force, and thus change the firm's capacity. Secondly firms are flexible in the work they are able to undertake, that is, they can change to meet a changing market. Thirdly firms are involved in quite a number of projects, and failure on one causes only limited damage to the firm as a whole.

A research project by the Building Economics Unit of University College London (1972), concerning the 'Mechanism of Response to Effective Demand', suggests that the fragmentation of the industry is a conditioned response to the arbitrary and fluctuating demand. The industry reacts by reducing the commitment to direct employees, and owned resources, by sub-contracting, hiring, etc. This study concentrated on the market for schools, and the degree of standardisation and use of standard components. Schools are a segment of the market particularly suitable for coordinating demand, and the use of standard components. They can thus highlight particular building inefficiencies. Other segments of the market, where projects are complex and unique, would perhaps not reveal inefficiences quite so clearly.

It is the ability to change direction to meet prevailing environmental circumstances that enables the industry to survive. Closer and perhaps more formal coordination would mean less flexibility and given these conditions, the fragmentation of the industry is perhaps a significant advantage.

1.6 PROJECT SUCCESS

Any building project will involve a variety of aspects of success. For the client a successful outcome might be completion of his building on time and within budget. For the professionals involved, success might be represented by a satisfied client and a trouble free project. The contractor will also be interested in a smooth running project but must be also concerned with financial return. However these goals may change. A contractor faced with Phase 1 of what might turn out to be a multi-phase project is likely to have client satisfaction as his primary objective in order to secure the remaining phases. Experience also suggests that, when difficulties arise, there can be a radical change in on-site motives and attitudes. Some may lead to acrimony and even legal action.

All organisations contain individuals whose personal objectives diverge from corporate ones. In the case of the contractor the shareholder has to be satisfied while directors, managers and operatives also have to contribute to gain satisfaction. Client satisfaction may differ in respect of the owner, the occupier or tenant, or the general public.

A further complication is that client satisfaction will, in many cases, depend upon the degree of conformity between expectations, interpretation of the brief, and realization of the project. When a designer is appointed, the accuracy of the brief is a measure of the ability of the designer to communicate, explain limitations, explain the relationship between cost and quality, and to translate client requirements. Client satisfaction is also affected by the designer's ability to set up proper systems of control, and the scope available to introduce variations arising from the clarification of misunderstandings.

A recent example of the measure of client satisfaction achieved by the industry is given by the NEDO Steering Group on Industrial Building and Infrastructure (Graves 1978). This group conducted a postal survey of industrial clients who had recently invested in new buildings, and found a high level of satisfaction. They were asked to express a level of satisfaction on five criteria, design and planning, construction, defect rectification, final cost, and time from design to completion. Interestingly, 215 respondents reported improvements in production layout, and 237 reported improvements in the working environment. Here subjective client judgements are offered retrospectively, presumably after clients have weighed performance against their expectations and experience.

Other measures have been developed by the National Swedish Board of Public Building, (KBS,1971) in an attempt to evaluate the merits of design proposals before construction. The Board tested evaluation models on two projects. The first, a Government administration block in Stockholm, was tested using two scales of value factors :-

1. Factors entailing some advantage referred to as 'quality factors'.

2. Factors entailing certain sacrifices, referred to as 'cost factors'.

A lower limit is set expressing an unacceptable level of minimum quality at maximum cost. There is a notional upper limit of maximum quality at minimum cost. Tenders are evaluated in terms of the two scales of 'quality factors' and 'cost' factors and this is expressed in money terms and plotted between the two extremes. The acceptable tender is the one which offers optimum value for money along these two scales.

The second evaluation technique tried by the National Swedish Board of Public Building involved a project for 200 small flats. Four package deal contractors tendered in competition, and their proposals were evaluated by time, price, and quality. These factors were subdivided into a total of 50 contributory factors, which were judged and given weightings by a panel of experts.

Similar evaluation procedures have been used in this country by the Post Office, (Cameron and Pearson 1973).

Original work has been done by the Building Performance Research Unit under Professor Markus (1967). The Unit's objectives were to devise and improve measurement and appraisal techniques for assessing building performance. They concentrated on schools and examined the performance of the buildings in objective terms and also obtained the subjective perception of performance by the clients and users.

However, in summary, the main aim of the building process must be to satisfy the client. This satisfaction may be a subjective opinion of the client but it is this opinion which the building team seeks to influence. There must, however, be rational grounds for the judgements made by the client. It would be impossible to enumerate all the diverse factors clients may require from a project but there are a number of primary categories that may be considered. These may include the general suitability of the building for the purpose for which it was commissioned, the price, and whether this represented value for money to the client, whether the project was on programme or not, and the degree to which the project is aesthetically pleasing to the client. Further considerations might be related to life cycle costing and good project relations.

It is undeniably true that in some cases the client may not be qualified to make some judgements and that his perception of his wants may differ from their realisation.

If the view is taken that it is the duty of all members of the building team to work in the interests of the client, then the responsibility to create a satisfactory product must ultimately lie with the team. If the client is dissatisfied, it may be that the team has both failed to work as a team, and that it has failed to make its members individually accountable for their actions.

CHAPTER 2 - MODELS OF THE BUILDING PROCESS

This chapter examines the models which have been used by previous researchers to investigate the organisation and operation of the building team, or of the building process. It develops the model used in pursuit of this research to investigate the variables within the building.

The social sciences exploit modelling techniques to represent or explain phenomena and relationships in the real world. The technique is explored and used to assist in the development of the research model. A model is a representation of reality. Hagget and Chorley (1967) discuss the functions of a model, which should provide a framework for the definition, collection and ordering of information. It should enable phenomena to be visualised and comprehended, and assist in explanation and comparison. Finally a model should communicate ideas.

A model can demonstrate relationships over a range of values, for example, a clock is both an analogue, and a dynamic model, to represent the passage of time. Graphical networks can represent the sequence of work activities for a construction project. The construction of models can aid understanding and permit prediction through measurement. Models may be descriptive, physical, conceptual or mathematical, (Echenique 1970).

The conceptual model adopted in this research is intended to stimulate the development of new theory, through better understanding of the configuration and causal interrelationships among postulated elements. The importance of causal relationships is emphasised by Hesse (1966) who also proposes the idea of positive, negative and neutral analogies which give expression to the agreement and dependence between relationships.

A model should consist of components which represent, or are thought to represent, discrete and identifiable components in the physical reality to be studied. These components may be constants or variables, and are related to each other within the model. A variable is anything which can assume more than one value. A model can stipulate the magnitudes which variables may assume under specific conditions. A variable may be independent so that, when varied, it appears to induce change in another variable. A dependent variable is a variable whose values change in response to changes in the independent variable. An intervening variable helps to explain linkages between variables, and a moderator variable is one which induces change in the relationship between other variables, (Stone 1978).

The research process should encompass the identification of the problem, and the development of a model, which is then tested against reality. The modelling technique selected should encompass all significant variables and sub-systems, show clearly the degree of inter-relatedness and interdependency and remain valid and useful across the required range of situations. The process should be iterative, bringing modifications to the model after testing against reality.

Models of the building process

Cleland and King (1968) in their study of systems analysis and project management, adopt a 'systems approach', as do Miller and Rice (1967) investigating the building of a new steel works, and Morris (1972) in his study of the building process. Cleland and King define the approach :-

> 'A systems approach by its very nature is made up of interdependent elements, actions which affect one element must affect others also, and actions of one element cause reactions on the part of others. The recognition of such interreactions and interdependencies both within and without the organisation is the essence of the systems viewpoint.'

Therefore the systems approach embraces the essential features of model building. The advantage of a systems model is that it emphasises wholeness and the existence of a set of interdependencies. It allows for complexity, and an indication of strength of association. In this respect, a systems model is appropriate to the study of building team organisation, in the initial stages of research. At later stages quantitative refinements may be employed.

Study of the building process reveals the complexity of the interrelationships, and the building project team can be seen as a sub-system within the supra-system involving the environmental aspects of the economy, technology, and legislation.

Models of the building process

Systems thinking and the concepts of open and closed systems were discussed originally by Koehler (1938), and Bertalanffy (1950), and more recently by Kast and Rosenzweig (1973). A systems approach requires two principal steps, first the determination of system boundaries and second the identification of sub-systems and relationships between sub-systems. Miller and Rice (1967) emphasise boundary definition in their study of the building of a new steel works. Few systems are completely closed and the building process is an open system by definition, since it has a continuous flow of component materials from the environment and a continuous output of products of the system back to the environment. Boundary definition is therefore extremely important.

Identification of sub-systems may generally be made by the processes they carry out and much of the model analysis of the building process has been concerned with this aspect. However, interfaces between sub-systems are often blurred and may be difficult to isolate completely. Attempts to construct models of the building process have generally taken one of two directions. Some models show the structure of the industry and how the various functions interrelate. Others show the processes involved in constructing projects. The first type tends to be static. Structural organisational models show the organisation of the industry at a particular point in time, rather like a company organisation chart. The second type of model shows the sequence of activities, generally from beginning to end of a construction project.

Models of the building process

It is extremely difficult to construct a model which elucidates the wide range of alternative systems which exist and interact within the building process. It is also difficult to indicate causality, that is, to show the direction and magnitude of the relationships between elements within the model. This makes it difficult to predict, monitor, and understand the building process.

The first group of structural models includes the work of Walters (1960), Baden-Hellard (1962) and Honey (1966). These illustrate two-dimensionally the primary relationships between the basic functional specialisms in the building process, and attempt to show, by nuances in the configuration, the differences between various contractual arrangements. Whilst useful for identifying the basic principles of contractual arrangement this type of modelling is limited in the capacity to show detail. It is also static and does not show how relationships and organisational structure change as the construction process develops.

The second model type attempts to overcome some of these shortcomings by adopting a temporal and processual approach. The 'Outline Plan of Work', published by the Royal Institute of British Architects (now in its 4th. edition, 1980), was one of the first expressions of the building process offered by members of the building team. This step-by-step analysis and grouping of essential processes into a number of well defined stages, eg scheme design, sketch design, detailed working drawings, etc. was given in tabular form with the members of the building team along the top. The matrix was filled in with the duties and responsibilities of each member at each stage in the process. However it infers a sequential process and does not illustrate the iterative and cyclic nature of the design and build process.

Models of the building process

The RIBA work was taken further by Turin (1972) in his study of the Building Timetable. Turin used a two-dimensional table to relate broad groupings of participants to the process and the sequence of building. He divided the building process into nine stages and identified eight different ways of organising or sequencing those stages. For each of the eight sequences the building team may be organised in one of five ways, eg., the client, design team and main contractor can be entirely independent. Alternatively the client and design team can be grouped together, separately from the contractor, or the design team and contractor can be grouped together, etc. Turin's model is ingenious and illustrates procedural and structural veriations.

The effect of change in organisation structure on behaviour is discussed by Honey (1966), who describes the changes in emphasis that occur when building technology tends towards system or component building. The changes in emphasis that are brought about in the design process are not usually shown by structural or processual models. These changes, according to Honey, are product-orientated and he gives examples of the consequences of a tendency towards system or component building as:-

1. The client loses an individually tailored building.
2. The designer becomes more closely linked with the manufacturer.
3. The contractor becomes an assembler.
4. Quality control becomes vital.

Models of the building process

This is one example of how a change in procedure or technology can have an influence on the building team whatever the configuration. It is probably true, however, that some configurations may be better able to cope with certain changes or procedural constraints than others. This of course depends on the flexibility and capabilities of both individuals and the group.

More recent research has been published by Cakin (1976) who has developed models of industrialised building based on the initiating body. Honey and Cakin both concentrate on the relationship with the component supplier, an element which dominates industrialised building but is not relevant across all situations.

Morris (1972) has used the RIBA/Walters model, and with the aid, principally, of Lawrence and Lorsch's work (1967) concerning differentiation and integration, he has studied the interfaces between the major processes. His principal concern was the relationships between the design and production functions, and the study of that interface.

Morris identifies three main process sub-systems:-

A - Design

B - Design Realisation

C - Construction

He used the model over six case studies to study the pattern of differentiation and integration by recording, first, the structural differentiation, and second, environmental differentiation. Together these provided a measure of 'total' differentiation at the sub-system interface. This total differentiation was then compared with the 'interfaces' integration by recording the following aspects of the project's integration; its method, its frequency and regularity, and the organisational level at which its co-ordinating bodies operate, and the memberships of those bodies.

Morris finds that co-ordination and control at the design/construct interface are difficult, not so much when its differentiation is large as when it is complex. The traditional system lacks the flexibility to cope with projects of this type, and newer organisational forms, (eg. project management), may be more sucessful when projects involve problems of speed or complexity. Although he has used a processual model, Morris has used it to investigate the organisational behaviour of building teams under different organisational characteristics (ie. different organisational forms).

Wearne (1969) also examined the building process. In particular he studied the internal structure of large engineering design departments in terms of numbers of co-ordinators, number of levels of authority and organisation structure. In further work (1971 and 1973) he examined the management of the project team, and emphasises the importance of technology, information feedback, flexibility, and contractual linking.

Models of the building process

Boland's morphology of the construction industry (1978), illustrates the interrelationships of various constituent parts of the industry. It is essentially a model of the industry in suspended animation - awaiting the stimulus (or input) of a building need to activate it.

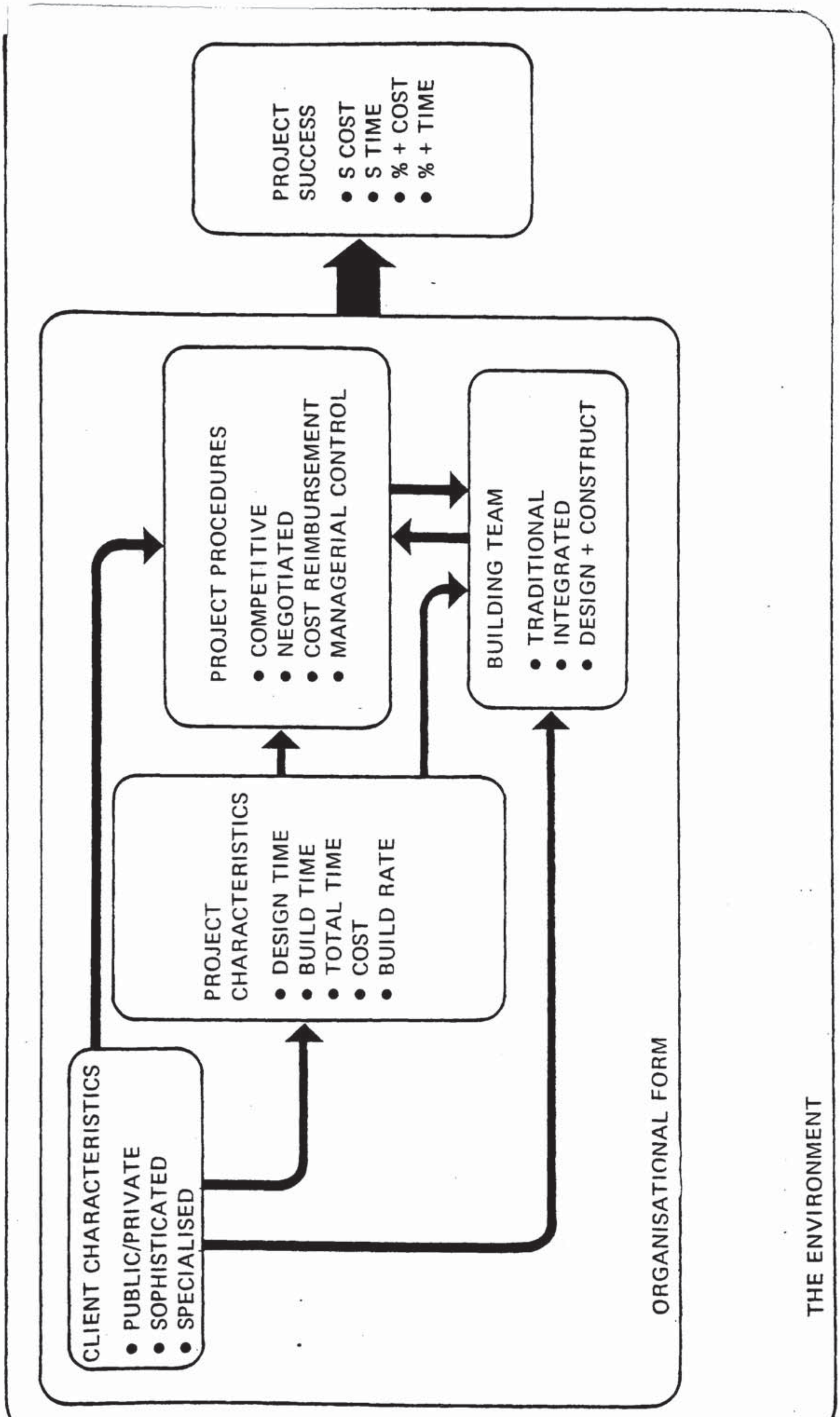
Once activated the construction industry proceeds through what is known as the building process to design, manage and build the building. The various models already discussed are attempts to illustrate the building process, to show the functions, interrelationships, responsibilities etc.

THE RESEARCH MODEL

The model sets out to illustrate the relationships between the variables in the building process. The objective of the model is that it might be used to assist in the selection of those organisational forms and project procedures that are appropriate to individual client and project characteristics, and that will therefore result in project success. The variables thought to be of principal relevance were discussed in Chapter 1, the research method and measurement of these variables is dealt with in Chapter 3.

The model differs from most of those discussed in this chapter, with perhaps the exception of Morris's, in that it does not attempt to show, in definitive terms, the structure or configuration of particular organisational forms. Instead it identifies the variables which influence any particular form. If the extent of these influences can be assessed, then organisational forms may be selected, or modified, to take account of them.

The model is given in figure 1. There are six elements or variables. The elements client characteristics and project characteristics are seen as primary independent variables. To operate the model one would start with an assessment of the characteristics of these two variables. In response to this the next two moderator variables, project procedures and building team, are selected or adapted in order to serve the needs of the two primary independent variables: the objective being to achieve optimum results on the fifth, dependent variable of success. The variables of client and project characteristics, project procedures, and building team, compose what is known as the organisational form. These variables, including success, are all subject to the influence of the sixth element of the model, the environment.



THE RESEARCH MODEL

FIGURE 1

CHAPTER 3 - THE RESEARCH STUDY

THE SAMPLE

Various methods of organisational research are discussed by Vroom (1971). The hypothesis to be investigated, (see Introduction), and the number of variables present, make the comparative case study approach most appropriate.

The sample was obtained by approaching clients, professional practices and contractors in the industry, asking for their co-operation. In this respect the sample cannot be said to be random, but neither was it stratified in any way. No stipulation was made as to client type, etc., except that the projects should not be minor works. Those who expressed a willingness to co-operate were either sent the questionnaire (see Appendix 2), or visited with it. They were asked to complete the questionnaire for recently completed building projects with which they were associated. Notes were made during subsequent discussions, and data were gained from drawings, specifications, bills of quantities and other documentation as well as from site visits. All respondents were very helpful. They were invariably senior people able to provide informed and competent information.

The total sample of 32 projects was taken in two phases. The first 11 case studies were made in spring 1977; in this study at least four members of the building team for each project were visited and interviewed. They represented the client, architect, quantity surveyor and builder. Extremely close agreement was found between each member of the team and therefore only one was consulted during a second phase of 21 during 1978. This was normally the client.

The characteristics of the sample are given in Figure 10 where it can be seen that there are 16 publicly funded and 16 privately funded projects. They cover a wide range of building types ranging in cost from £0.16m to £11m.

THE MODEL

The model developed in the research was shown in Figure 1 and is intended to provide both a framework for examining various organisational forms and a vehicle for examining the relationships between the variables within the model.

THE VARIABLES

The variables measured are those suggested by the research model and are detailed below, followed by the mnemonic used for computer operations. Full details of the scoring for each of the variables is given in appendix 3.

<u>Client characteristics</u> <u>Computer mnemonic</u>

1. client type...................CLIENT
2. Client sophistication.........SOPHIS
3. Client specialisation.........SPECAL

Project characteristics

4. Project cost..................COST
5. Design time in months.........DSTIME
6. Build time in months..........BLTIME
7. Total time in months..........TOTAL
8. Rate of building..............BLRATE

Building team

9. Traditional pattern...........TRAD
10. Integrated pattern............INTEG
11. Design and construct..........D+C

Project procedures

12. Competition...................COMPET
13. Negotiation...................NEG
14. Cost reimbursement............REIMB
15. Managerial control............CONTRL

Project success measures

16. Client satisfaction on cost...SCOST
17. Client satisfaction on time...STIME
18. Percentage overrun on cost....%+COST
19. Percentage overrun on time....%+TIME

HYPOTHESES

The principal hypothesis is:-

> 'When the building team and project procedures are appropriate to client and project characteristics, higher levels of success will be attained'

In order to examine the general hypothesis, detailed hypotheses are expressed as follows:-

1. Client and project characteristics.
   - 1.1 Project characteristics are a function of client characteristics.
   - 1.2 Project success is a function of client characteristics.
   - 1.3 Project success is a function of project characteristics.

2. Building team.
   - 2.1 Building team is a function of client characteristics.
   - 2.2 Building team is a function of project characteristics.
   - 2.3 Project success is a function of building team.

3. Project and control procedures.
    - 3.1 Project procedures are a function of client characteristics.
    - 3.2 Project procedures are a function of project characteristics.
    - 3.3 Project procedures are a function of building team.
    - 3.4 Project success is a function of project procedures.

METHOD OF ANALYSIS

The techniques that have been used to assist in the analysis and evaluation of the results are :-

Contingency tables

These have been prepared manually and by computer and are useful for illustrating sample characteristics and permit the use of the chi square test.

Chi Square Test

This has been used to identify relationships within the contingency tables. It was necessary to express the tables in a 2x2 or 3x2 matrix in order to comply with the requirements of chi square calculation,ie. all cell values should preferably be not less than 5, and never less than 1, (Siegel 1956). Bearing in mind the exploratory nature of this research, results with a 90%

confidence level were considered worthy of discussion, ie. the probability that the nul hypothesis is true is less than 0.1.

Pearson's Correlation Coefficient

Correlations were calculated by computer for the entire matrix of variables. The data were ordinal and nominal. Pearson's correlation coefficient was used rather than Spearman's correlation coefficient because the nature of the data would have involved too many tied ranks which is not satisfactorily handled by Spearman, (Siegel 1956). Correlations express strength of association between two variables. The correlation squared indicates the proportion of variance in one variable which is explained by variation in the other. Results with a 90% confidence level were considered worthy of discussion, this sample size provides this level of confidence with correlation coefficients of 0.28 and above (Murdock and Barnes 1974).

McQuitty Analysis

This technique was used to build up an idea of the linkage of the relationships and is extremely useful in model validation, (McQuitty 1967).

Scattergrams

Over 100 scattergrams were produced by computer to illustrate the spread of results for different combinations of variables.

CHAPTER 4 - RESULTS

INTRODUCTION

This chapter will examine the evidence for each of the hypotheses given in chapter 3. Each of the hypotheses will be broken down into detailed sub-hypotheses which are expressed in the nul form for purposes of applying the tests of association. These sub-hypotheses are written out in detail for the first hypothesis, but subsequent ones are expressed in tabular form to save space. Correlation coefficients of 0.28 or above, were considered relevant. They indicate that at least 7% of the variation in the dependent variable is attributable to the independent variable. Otherwise the nul hypothesis is accepted. Individual results are not given within the text but may be seen in the appendices. Correlation coefficients are given in appendix 5, and the significant chi square test results in appendix 6. The full data matrix of scores from the questionnaires for each case study against each variable is given in appendix 4.

CLIENT AND PROJECT CHARACTERISTICS

HYPOTHESIS 1.1 Project characteristics are a function of client characteristics.

The results will be examined in terms of the publicly funded versus privately funded characteristic first, and then in terms of project cost, design time, build time, total time and build rate. In each case sub-hypotheses are postulated in the form of the nul hypothesis. Conclusions will be summarised at the end of the chapter.

Client type

Of the 32 case studies 16 were publicly funded and 16 privately funded. Further categorisation by building type is given in figure 2.

The variables sophistication and specialisation were an attempt to examine the influence which might occur when a client had built either a number of projects before (sophistication), or a number of similar projects before (specialisation). Under these circumstances it would be reasonable to assume that the client should be more experienced and the project possibly more successful. Twenty two clients were classed as highly sophisticated ie. they had built projects before, but only 6 (who were all private) were scored as being highly specialised because they had repeated a similar building. (These latter were cases 5,17,18,28,29,30, see figure 2, which shows they had specialised in industrial buildings).

Sub-hypothesis 1.1.1	The nul hypothesis is that the clients who are publicly funded and those who are privately funded do not differ in their degree of sophistication, (prior experience of building).
Sub-hypothesis 1.1.2	The nul hypothesis is that the clients who are publicly funded and those who are privately funded do not differ in their degree of specialisation, (prior experience of the same type of building).

THE RESEARCH SAMPLE, SHOWING TYPE OF BUILDING PROJECT AND CLIENTS' SOURCE OF FUNDING

BUILDING TYPE	CLIENT FUNDING				TOTALS
	PUBLIC CASE NO.	TOTALS	PRIVATE CASE NO.	TOTALS	
UNIVERSITY RESIDENCES *	1, 2, 3	3	31, 32	2	5
UNIVERSITY LIBRARY	11	1			1
COMMERCIAL	4	1	21, 22	2	3
OFFICES	6	1	10, 12, 13, 23	4	5
INDUSTRIAL			5, 17, 18, 19 28, 29, 30	7	7
AMENITY CENTRE	7	1			1
HOUSING	8, 9	2			2
AIRPORT BUILDINGS	14, 15, 16	3			3
BANK			20	1	1
MILITARY	24, 25, 26, 27	4			4
TOTALS		16		16	32

* - TWO CASES OF UNIVERSITY RESIDENCES WERE PRIVATELY FUNDED BY THE UNIVERSITY CONCERNED WITHOUT SUPPORT OR CONTROL FROM THE UNIVERSITY GRANTS COMMITTEE. OTHER RESIDENCES WERE PARTIALLY FUNDED BY THE U.G.C.

FIGURE 2

TYPE OF CLIENT FUNDING AND CLIENT SPECIALISATION

HYPOTHESIS 1.1.2

CLIENT FUNDING	CLIENT NOT SPECIALISED	CLIENT SPECIALISED	TOTALS
PUBLIC	16	0	16
PRIVATE	10	6	16
TOTALS	26	6	32

- CHI SQUARE P < 0.01
- CORRELATION R = 0.50

FIGURE 3

Results
Client and project characteristics

The chi square test and correlation coefficients supports sub-hypothesis 1.1.1, but do not support hypothesis 1.1.2. Therefore we can reject the nul hypothesis 1.1.2, and conclude that clients who are privately funded are more specialised than those who are publicly funded. There were no specialised publicly funded clients in the sample, (see figure 3). Since those clients who were highly specialised had built industrial buildings, another interpretation of the results might be that the industrial buildings field is narrow and highly specialised and such buildings are built by privately funded clients. On the other hand publicly funded clients are involved with a much more diverse range of projects and have less opportunity to develop specialisation.

Cost

Sub-hypothesis 1.1.3 — The nul hypothesis is that there is no difference between the cost of projects built by those clients who are publicly funded and those built by clients who are privately funded.

No particular bias was intended in the choice of private and public projects and their cost. Figure 7 is the scattergram of project cost against building time and indicates that all but two of the private projects cost less than £5m whereas many of the public projects cost more than £5m. This result might be anticipated since it is likely that proportionately more publicly funded projects are of large scale and thus of greater overall value. In the sample these are airport buildings, university buildings, local authority housing schemes etc. It might therefore be expected that this brings other differences in performance. If we dichotomise on the basis of greater or less than £5m the chi square test and correlation coefficient indicate that the probability of there being no association between cost and client funding is low, so we may reject the nul hypothesis and conclude that there is a relationship between client type and cost in that publicly funded clients build projects of higher cost.

Design Time

Sub-hypothesis 1.1.4 The nul hypothesis is that there is no difference in design time between the publicly funded and privately funded projects.

It is generally believed, in the industry, that the pre-contract period for public projects tends to be longer because public clients have more committees and other types of procedures to satisfy. The contingency table in figure 4 suggests that public clients do have longer design times, and when the chi square test and correlation are applied the results suggest that the nul hypothesis should be rejected. We may conclude that publicly funded projects have longer design times than privately funded projects.

This result should be interpreted with care however, for as the graph in figure 5 shows, two publicly funded projects, (case studies 8 and 9), had particularly long design times. The design times for these cases were difficult to assess because they represented two contracts for the same

TYPE OF CLIENT FUNDING AND
DESIGN TIME (IN MONTHS)

HYPOTHESIS 1.1.4

CLIENT FUNDING	DESIGN TIME (MONTHS)									
	0 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 +	TOTALS
PUBLIC	1	6	2	2	2	1			2	16
PRIVATE	11	3			2					16
TOTALS	12	9	2	2	4	1			2	32

WHEN DATA DICHOTOMISED AT 20 MONTHS
- CHI SQUARE P < 0.01
- CORRELATION R = -0.47

FIGURE 4

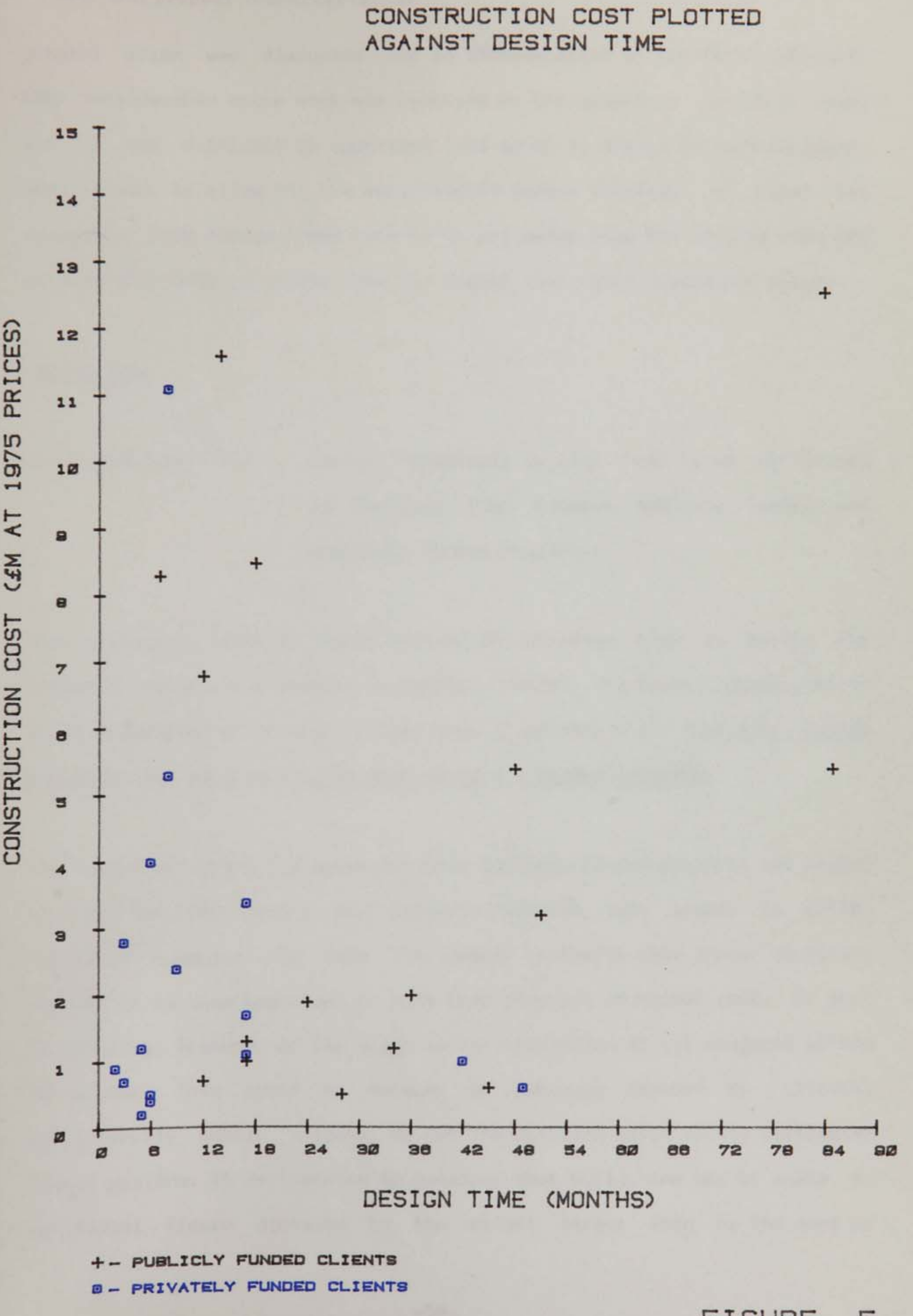

CONSTRUCTION COST PLOTTED
AGAINST DESIGN TIME
CONSTRUCTION COST (£M AT 1975 PRICES)
DESIGN TIME (MONTHS)
+ - PUBLICLY FUNDED CLIENTS
▫ - PRIVATELY FUNDED CLIENTS

FIGURE 5

project which was disrupted due to determination of the first contract. Some considerable extra work was required by the architect in this case, and it was difficult to apportion time spent on design to each contract, and, indeed, to allow for the considerable delays involved. If these two unusually long design times were to be set aside from the results then the relationship between client type and design time would clearly be weaker.

Build Time

Sub-hypothesis 1.1.5 The nul hypothesis is that there is no difference in building time between publicly funded and privately funded projects.

The contingency table in figure 6 gives the building time in months for projects which are privately or publicly funded. The tests indicate, based on dichotomising at greater or less than 25 months, that publicly funded projects take longer to build than privately funded projects.

The graph in figure 7 illustrates that publicly funded projects are higher in cost. The tests confirm that projects over £5m take longer to build. Figure 7 supports the view that public contracts take longer to build, however it is also important to note that they are of higher cost. A most interesting feature of the graph is the completion of all projects within 48 months. This could be because of pressure imposed by clients, particularily public clients, to get the building built within particular fiscal periods. It is tempting to consider that build time may be quite an artificial figure dictated by the client rather than by the cost or

TYPE OF CLIENT FUNDING AND
BUILDING TIME (IN MONTHS)

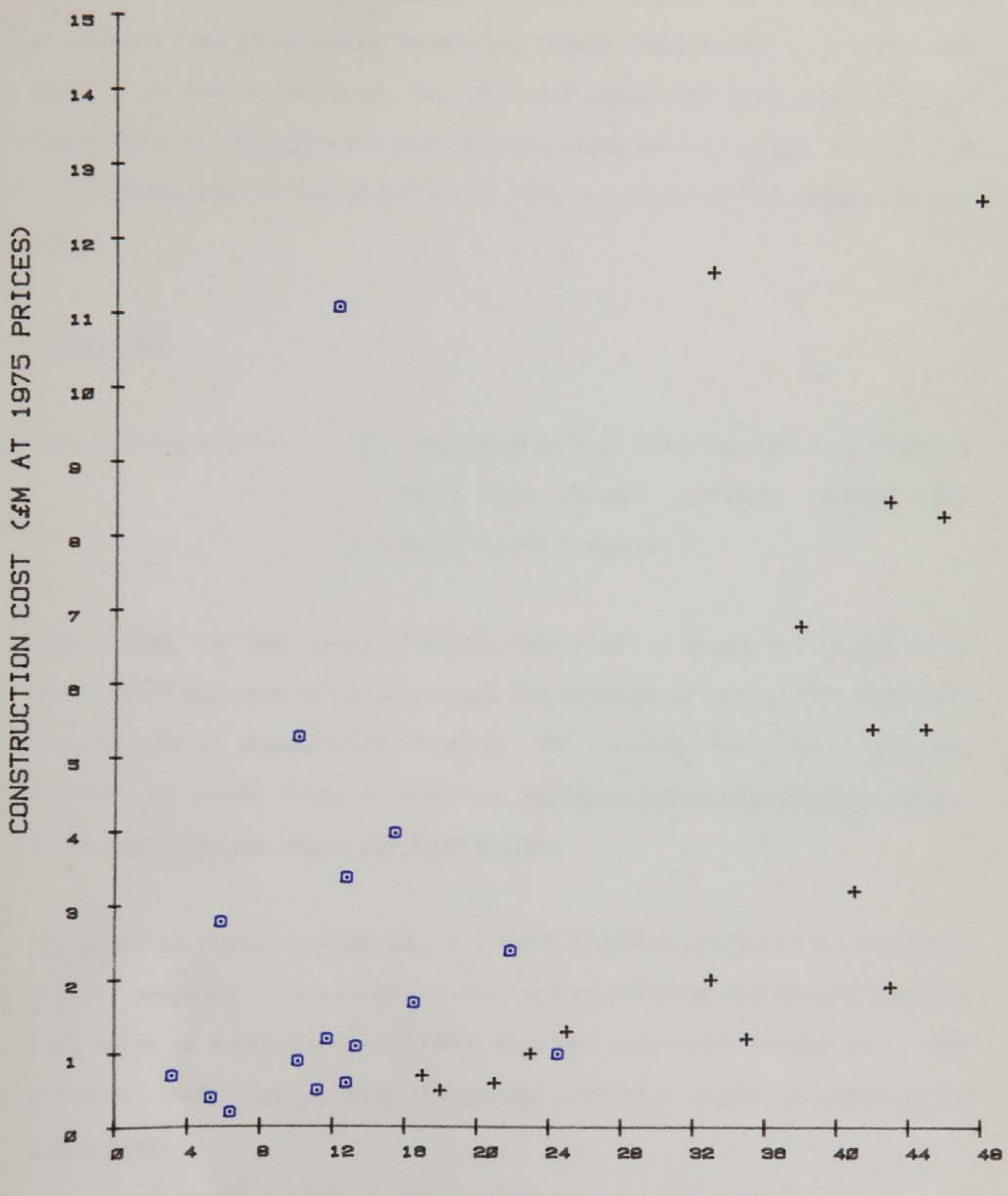
HYPOTHESIS 1.1.5

CLIENT FUNDING	BUILDING TIME (MONTHS)									
	0 - 10	11 - 15	16 - 20	21 - 25	26 - 30	31 - 35	36 - 40	41 - 45	46 +	TOTALS
PUBLIC			2	3		2	2	4	3	16
PRIVATE	1	3	2	4	3	1		1	1	16
TOTALS	1	3	4	7	3	3	2	5	4	32

WHEN DATA DICHOTOMISED AT 25 MONTHS
- CHI SQUARE $P < 0.05$
- CORRELATION $R = -0.50$

FIGURE 6

CONSTRUCTION COST PLOTTED AGAINST BUILDING TIME



+ – PUBLICLY FUNDED CLIENTS

⊡ – PRIVATELY FUNDED CLIENTS

FIGURE 7

complexity of the project. In this case it might be appropriate to assume that contractors can gear themselves up to complete any project within a stipulated time given enough resources, though there may be a hidden cost penalty in the project cost. This does not agree with other research which indicates a relationship between cost and time, however study of such a relationship was not the objective of this research, and the sample was not large.

Total Time

Sub-hypothesis 1.1.6 The nul hypothesis is that there is no difference in total time between publicly funded and privately funded projects.

Total time is the number of months from start of design to completion of the project and does not always equal the addition of design time and build time because of design/build overlap. The results for total time are similar to build time, in that the publicly funded projects took longer total time than the privately funded ones.

The graph in figure 8 shows cost and total time for publicly and privately funded projects. The chi square test and correlation coefficient indicate that there is a relationship between cost and total time. Therefore we may conclude that the greater the overall cost of a project the greater the total time.

CONSTRUCTION COST PLOTTED AGAINST TOTAL TIME

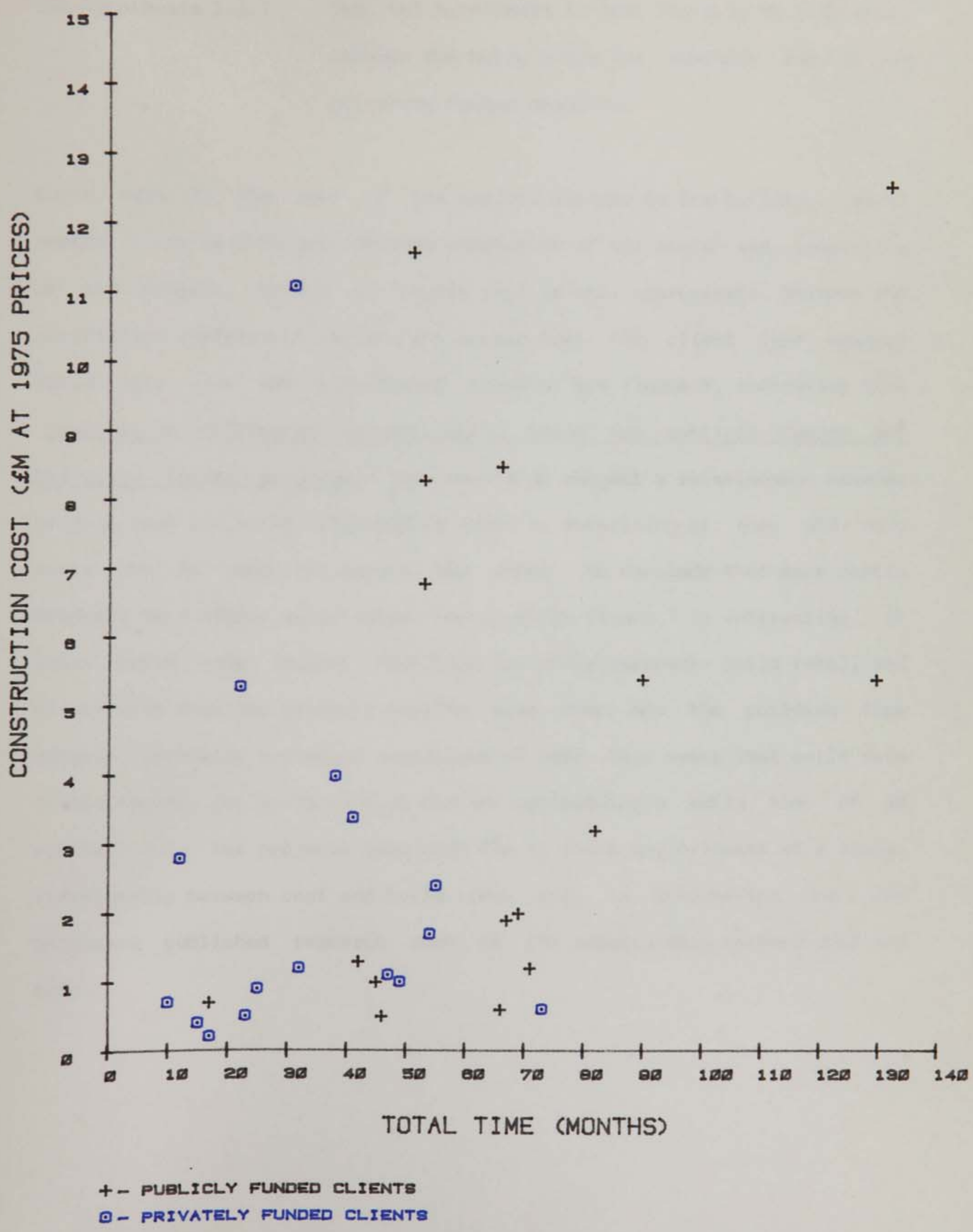


FIGURE 8

Results
Client and project characteristics

Build Rate

Sub-hypothesis 1.1.7 The nul hypothesis is that there is no difference between the build rates for publicly funded and privately funded projects.

Build rate is the cost of the project divided by the building time in months. It is used to provide some indication of the scale and complexity of the project, though of course this is only approximate. Neither the correlation coefficient nor the chi square test for client type against build rate give any significant results, see figure 9, indicating that there is no difference between build rates for publicly funded and privately funded projects. The results do suggest a relationship between project cost and build rate, but it would be surprising if they did not, since one is used to derive the other. We conclude that more costly projects have higher build rates. The graph in figure 7 is interesting, it shows build time against cost (and therefore expresses build rate), and illustrates that for projects costing more than £5m the building time remains virtually unchanged regardless of cost. This means that build rate climbs rapidly for projects over £5m and approaching a build time of 48 months. Only for projects less than £5m is there any evidence of a linear relationship between cost and build time. This is interesting when one considers published research work on the relationship between cost and time.

TYPE OF CLIENT FUNDING AND BUILD RATE
(AVERAGE MONTHLY EXPENDITURE)

HYPOTHESIS 1.1.7

CLIENT FUNDING	BUILD RATE (£,000 PER MONTH)									
	0 - 25	26 - 50	51 - 75	76 - 100	101 - 125	126 - 150	151 - 175	176 - 200	201 +	TOTALS
PUBLIC		6	2	1		2		3	2	16
PRIVATE	3	4	3		1	2			3	16
TOTALS	3	10	5	1	1	4		3	5	32

WHEN DATA DICHOTOMISED AT £100,000 PER MONTH
- CHI SQUARE P = 0
- CORRELATION R = -0.02

FIGURE 9

CLIENT CHARACTERISTICS AND PROJECT SUCCESS

HYPOTHESIS 1.2 Project success is a function of client characteristics.

Two sets of measures were used to represent project success. First the levels of satisfaction expressed by the client concerning cost and time, were each expressed on a three point scale, (SCOST and STIME). Secondly, actual performance on cost and time, measured by percentage increase or overrun on budget in pounds, and percentage time overrun, measured in months, (%+COST and %+TIME). Detailed sub-hypotheses are expressed in the form of the nul hypothesis.

Sub-hypothesis 1.2.1 The nul hypothesis is that there is no difference in the level of satisfaction with cost between publicly funded and privately funded clients.

Sub-hypothesis 1.2.2 The nul hypothesis is that there is no difference in the level of satisfaction with time between publicly funded and privately funded clients.

The chi square test and correlation coefficient indicate that we can reject the nul hypothesis 1.2.1 and conclude that the publicly funded clients were less satisfied with cost performance than were privately funded clients. However the test results support hypothesis 1.2.2 that there is no difference in the level of satisfaction with time between publicly funded and privately funded clients.

Sub-hypothesis 1.2.3 The nul hypothesis is that there is no difference in the level of percentage cost overrun between publicly funded and privately funded clients.

Sub-hypothesis 1.2.4 The nul hypothesis is that there is no difference in the level of percentage time overrun between publicly funded and privately funded clients.

When the tests are applied to the data dichotomised at greater or less than +10% cost overrun the results allow us to reject the nul hypothesis and conclude that the publicly funded projects exceeded the budget more often than the privately funded ones. The data may be seen in the graph in figure 10.

The distribution of the data for percentage time overrun is erratic, as may be appreciated from the graph in figure 11 which indicates greater likilyhood of time overrun for publicly funded projects. When the tests are applied to the data dichotomised at +25% time overrun they indicate that the nul hypothesis can be rejected, and we may conclude that the publicly funded projects overrun more on time than the privately funded ones.

CONSTRUCTION COST PLOTTED
AGAINST PERCENTAGE OVERRUN ON BUDGET

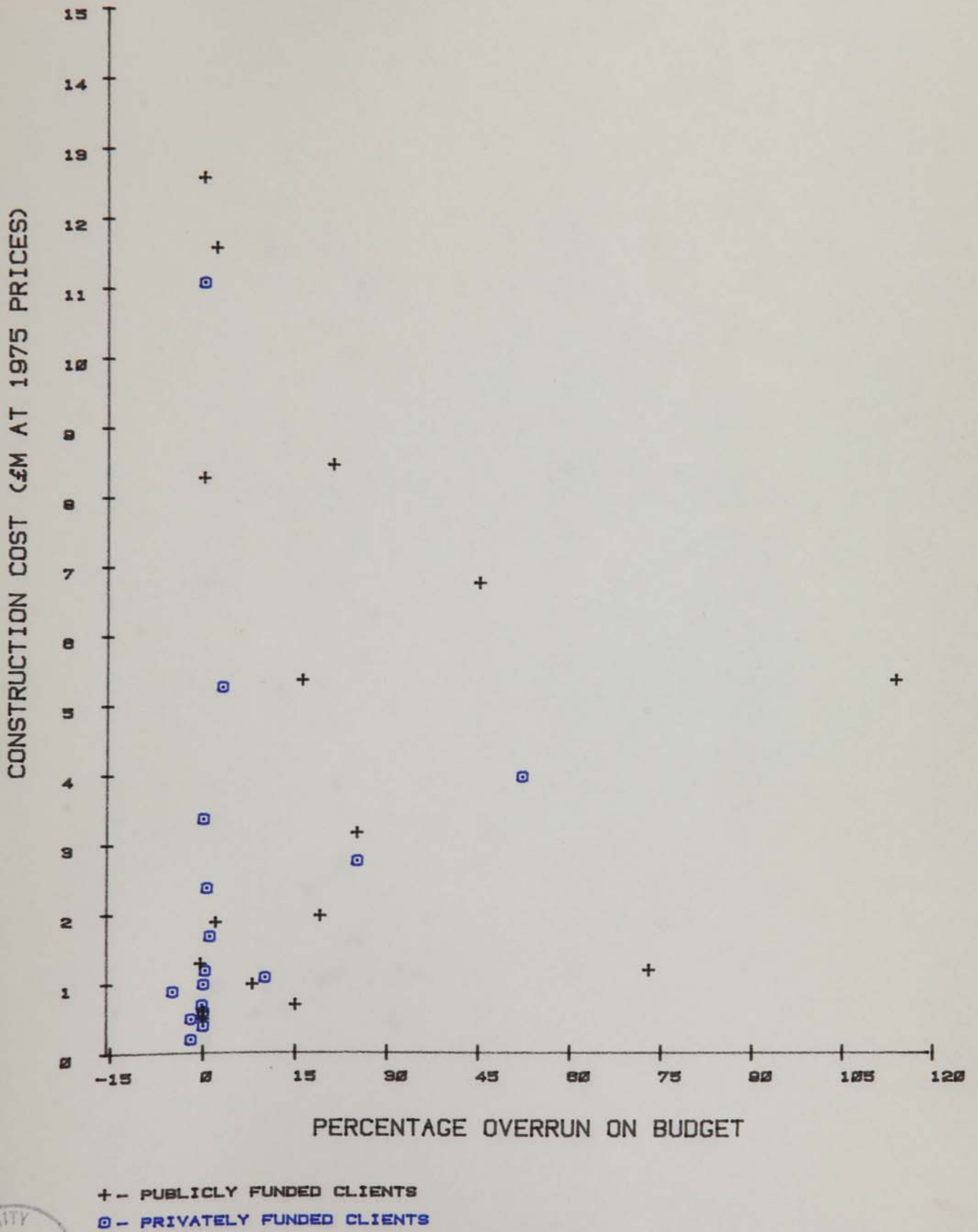


FIGURE 10

CONSTRUCTION COST PLOTTED
AGAINST PERCENTAGE OVERRUN ON TIME

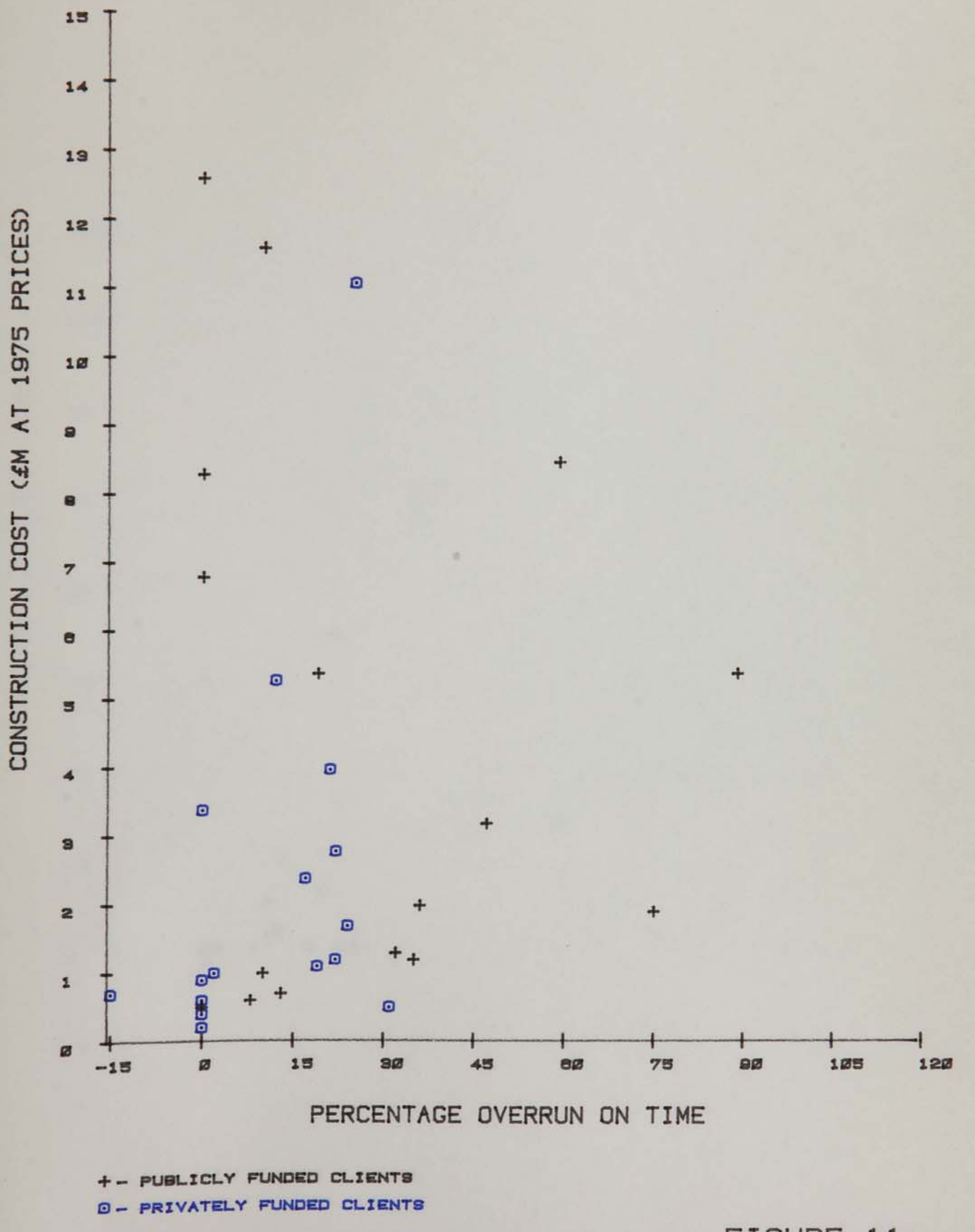


FIGURE 11

PERCENTAGE OVERRUN ON BUDGET PLOTTED AGAINST PERCENTAGE OVERRUN ON TIME

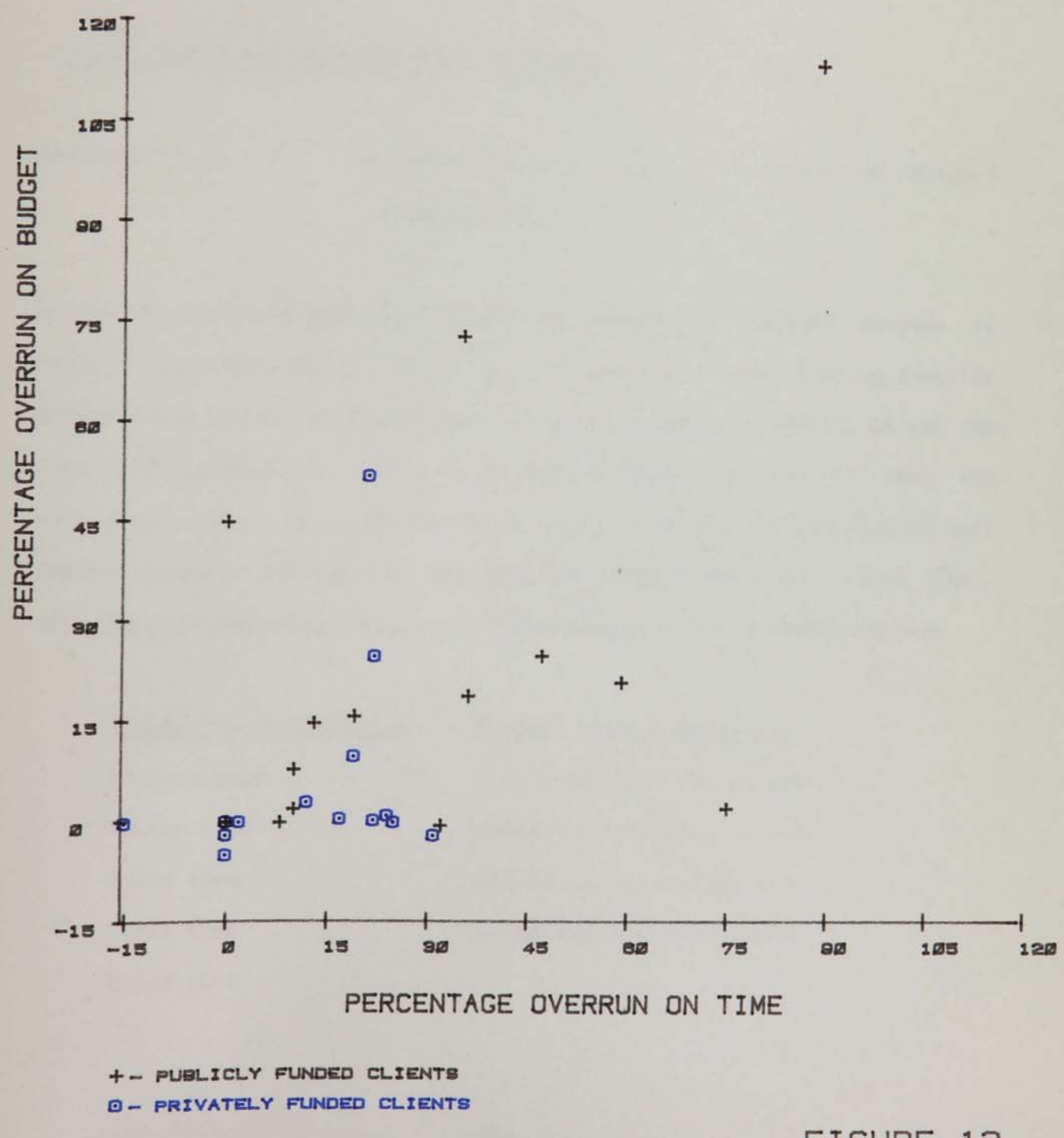


FIGURE 12

Figure 12 combines percentage overrun on cost and time and indicates (by observation) that slightly more projects exceed the programmed time than the budget, and that publicly funded projects performed less well than privately funded projects. The tests confirm this, that projects that overrun on budget also overrun on time.

PROJECT CHARACTERISTICS AND PROJECT SUCCESS

HYPOTHESIS 1.3 Project success is a function of project characteristics.

Within this broad hypothesis relating the measures of project success to project characteristics, there are 20 sub-hypotheses linking specific measures and characteristics. They are not enunciated in detail, as was the case with hypotheses 1.1 and 1.2, in order to save space but all take the nul form:- 'there is no difference in level of client satisfaction on cost between projects costing less than £5m and those costing more than £5m', etc. The sub-hypotheses relate the variables given in the table below:-

Project characteristics	Project success measures
Project cost	client satisfaction on cost
Design time	client satisfaction on time
Build time	percentage overrun on cost
Total time	percentage overrun on time
Build rate	

Reference back to figure 12 indicates that slightly fewer projects overran on cost than on time. This is to be expected, since cost is more easily controlled and can be recovered by variations of omission, whereas time is absolute, and, when lost, is very difficult to recover. Also clients, particularly public clients, wish to keep very tight control over cost, but do not place the same value on time. Furthermore, discrepancies in time are only to be expected when build time seems to be decided arbitrarily, and not in relation to project cost. (See figure 7, with its abrupt cut-off point at 48 months).

Figure 13 shows that project cost, as a project characteristic, is not related to the four success variables listed. A cost of less than £5m, or more than £5m, is a measure of size, distinguishing between big and small projects, either of which can be successful, given appropriate team and project procedures. Dissatisfaction on cost arises not from cost itself, but from cost overrun (see appendix 5).

In figure 13, the other correlations suggest that from 7% (r=0.28) to 20% (r=0.45) of the variation in any particular success measure can be explained by variations in design time, build time, and total time. The chi square test supports certain of the relationships, but suggests that chance could play a part in the relation between design time and success overall (the second row), and between total time and time overrun. We may confidently conclude that <u>projects that took less time to build, and less total time, gave a higher level of client satisfaction on time, and overran the budget by less.</u>

CORRELATION COEFFICIENTS BETWEEN PROJECT CHARACTERISTICS AND SUCCESS MEASURES

HYPOTHESIS 1.3

PROJECT CHARACTERISTICS	SUCCESS MEASURES			
	CLIENT SATISFACTION ON COST	CLIENT SATISFACTION ON TIME	PERCENTAGE OVERRUN ON COST	PERCENTAGE OVERRUN ON TIME
COST	0.05	0.11	0.11	0.09
DESIGN TIME	-0.29	-0.30	0.41	0.33
BUILD TIME	-0.28	-0.40 *	0.33 *	0.45 *
TOTAL TIME	-0.32 *	-0.42 *	0.45 *	0.45
BUILD RATE	0.16	0.28	0.04	0.00

* - SIGNIFICANT AT P < 0.025
ALL OTHER CORRELATIONS
ARE NON SIGNIFICANT

FIGURE 13

BUILDING TEAM

HYPOTHESIS 2.1 Building team is a function of client characteristics.

Figure 14 is a detailed analysis by building type and shows, contrary to popular belief, that, at least in this sample, design and construct is not confined to any particular building type . It is generally thought that private clients are more likely to adopt design and construct because they have fewer constraints than public clients and 5 out of 7 of the users of design and construct were privately funded. However, it is interesting to note that all the office buildings and most of the industrial premises were run on either the traditional basis or by integrated teams. Nevertheless the chi square test does indicate that the nul hypothesis should be rejected. If the sample were random we could say that publicly funded clients are less likely to adopt design and construct than private clients. No significant relationships were found for the other forms, and for them the nul hypothesis is accepted.

CLIENT FUNDING AND BUILDING TYPE RELATED TO BUILDING TEAM CHARACTERISTICS

HYPOTHESIS 2

BUILDING TYPE	FUNDING	BUILDING TEAM			TOTALS	
		TRADITIONAL	INTEGRATED	DESIGN AND CONSTRUCT		
UNIVERSITY RESIDENCES	PU	1, 2	3		3	5
	PR			31, 32	2	
UNIVERSITY LIBRARY	PU		11		1	1
	PR					
COMMERCIAL	PU			4	1	3
	PR	22		21	2	
OFFICES	PU	6			1	5
	PR	10, 12, 13, 23			4	
INDUSTRIAL	PU					7
	PR	18, 19, 30	5, 17, 19	28	7	
AMENITY CENTRE	PU		7		1	1
	PR					
HOUSING	PU	8	9		2	2
	PR					
AIRPORT BUILDINGS	PU	15	14, 16		3	3
	PR					
BANK	PU					1
	PR			20	1	
MILITARY	PU	26	14, 25	27	4	4
	PR					
TOTALS		14	11	7		32

PU - PUBLICLY FUNDED
PR - PRIVATELY FUNDED

THE NUMBERS IN THE CELLS ARE CASE CODE NUMBERS

FIGURE 14

HYPOTHESIS 2.2 Building team is a function of project characteristics.

Within this broad hypothesis relating building team to project characteristics there are 15 sub-hypotheses linking specific forms and characteristics. They are not enunciated in detail, but all take the nul form and relate the variables given in the table below:-

Building team	project characteristics
Traditional	project cost
Integrated	design time
Design and construct	build time
	total time
	build rate

The chi square test and contingency tables were examined for building team against cost, design time, build time, total time, and build rate. The results suggest that the nul hypothesis can be rejected in respect of the following:- Integrated teams, as opposed to non integrated teams, are used on higher cost projects, and projects with higher build rates. Design and construct, as opposed to other forms, is associated with projects that have shorter build times and shorter total times.

HYPOTHESIS 2.3 Project success is a function of building team.

Within this broad hypothesis relating the measures of project success to building team there are 12 sub-hypotheses linking specific measures and forms. They are not enunciated in detail, but all take the nul form and relate the variables given in the table below:-

Project success measures	Building team
Satisfaction on cost	traditional
Satisfaction on time	integrated
Overrun on cost	design and construct
Overrun on time	

The results for the chi square test applied to each of these sub-hypotheses are given in figure 15 together with the significant correlation coefficients, and indicate that <u>integrated teams gave a marginally lower level of client satisfaction on time.</u> The results also indicate that <u>design and construct gave a higher level of client satisfaction on time, and overran less on time.</u>

CORRELATION COEFFICIENTS BETWEEN BUILDING TEAM AND SUCCESS MEASURES

HYPOTHESIS 2.3

BUILDING TEAM	SUCCESS MEASURES			
	CLIENT SATISFACTION ON COST	CLIENT SATISFACTION ON TIME	PERCENTAGE OVERRUN ON COST	PERCENTAGE OVERRUN ON TIME
TRADITIONAL	-0.12	-0.13	0.07	-0.00
INTEGRATED	-0.07	-0.19 *	0.07	0.26
DESIGN AND CONSTRUCT	0.22	0.38 *	-0.17	-0.30 *

* - SIGNIFICANT AT P < 0.025
ALL OTHER CORRELATIONS
ARE NON SIGNIFICANT

FIGURE 15

PROJECT PROCEDURES

HYPOTHESIS 3.1 Project procedures are a function of client characteristics.

The majority of projects were let on a competitive basis regardless of whether clients were publicly or privately funded. No significant results were apparent from the chi square test or correlation coefficient, therefore the nul hypothesis is upheld that project procedures do not appear to be a function of client characteristics.

HYPOTHESIS 3.2 Project procedures are a function of project characteristics.

This broad hypothesis relating project procedures and project characteristics was treated in a similar manner to other hypotheses, that is, it was broken down into detailed sub-hypotheses of which there were 20. For project procedures, the sample included only three cost reimbursement contracts. Therefore the data was dichotomised on the basis of competitive (risk bearing) procedures versus non-competitive procedures which included negotiated contracts as well as the three cost reimbursement contracts. The variable control is a measure of the procedures and arrangements for controlling, monitoring and managing the building process. In practice most cases had fairly traditional arrangements. However six projects had higher levels of managerial control, some form of project management, construction management etc.

The table below shows the procedural variables related to the project characteristics by the nul hypothesis.

Project procedure	Project characteristic
Competitive	project cost
Non-competitive	design time
(negotiated and	
cost reimbursement)	build time
Control	total time
	build rate

The chi square test result, for competitive versus non-competitive procedures, dichotomised in this way indicates that competitive procedures have shorter design times, and total times, than non competitive procedures. The results also indicate that higher levels of managerial control are associated with projects having higher build rates.

HYPOTHESIS 3.3 Project procedures are a function of building team.

The results for these variables were examined by the chi square test in the form of nul hypotheses following the table below:-

project procedures	building team
Competitive	traditional
Non-competitive	integrated
(negotiated and	
cost reimbursement)	design and construct
Control	

There are two interesting results here, firstly projects handled by integrated teams are not those let by competition, indicating that integrated teams may tend to choose non competitive methods of appointing contractors. Secondly the traditional form has a lower level of managerial control than non traditional teams. This suggests that one difference between traditional teams and other teams such as project management, construction management etc., could be in the level of managerial control.

HYPOTHESIS 3.4 Project success is a function of project procedures.

Within this broad hypothesis relating the measures of project success to project procedures there are 12 sub-hypotheses linking specific measures and procedures. They are not enunciated in detail but all take the nul form and relate the variables given in the table below:-

Project success measures	project procedure
satisfaction on cost	competitive
satisfaction on time	non competitive
	(negotiated and
overrun on cost	cost reimbursement)
overrun on time	control

The results for the chi square test and correlations applied to the sub-hypotheses linking these variables are given in figure 16. The results show that non competitive procedures overrun less on cost. There are significant relationships between control and all of the success measures, indicating that the level of control is an important element of project success. We may conclude that managerial control is a potent factor in achieving project success.

CORRELATION COEFFICIENTS BETWEEN PROJECT PROCEDURES AND SUCCESS MEASURES

HYPOTHESIS 3.4

PROJECT PROCEDURES	SUCCESS MEASURES			
	CLIENT SATISFACTION ON COST	CLIENT SATISFACTION ON TIME	PERCENTAGE OVERRUN ON COST	PERCENTAGE OVERRUN ON TIME
COMPETITIVE	0.01	-0.04	0.24*	-0.03
NEGOTIATION	0.07	0.03	-0.21	0.02
COST REIMBURSEMENT	-0.10	0.02	-0.09	0.02
MANAGERIAL CONTROL	0.45 *	0.31 *	-0.37 *	-0.38 *

* - SIGNIFICANT AT $P < 0.025$
ALL OTHER CORRELATIONS
ARE NON SIGNIFICANT

FIGURE 16

INTER-RELATIONS AMONG SUCCESS MEASURES

Inter-comparison of the success measures, their chi square test results and the correlation coefficients are shown in figure 17. The agreement between the measures is high, as might be expected. The results show that the covariation between client satisfaction with performance on cost, and client satisfaction with performance on time amounts to about 43% of their combined variation (r=0.66). The level of satisfaction on cost did, indeed, reflect the actual percentage overrun on cost, and also reflected the actual percentage overrun on time. Similarily the level of satisfaction expressed by clients on time was in accord with the actual percentage overrun on time, and also reflected the percentage overrun on cost. There was very close agreement between percentage overrun on time and percentage overrun on cost (see figure 12).

MATRIX OF CORRELATION COEFFICIENTS
BETWEEN SUCCESS MEASURES

SUCCESS MEASURES	SUCCESS MEASURES			
	CLIENT SATISFACTION ON COST	CLIENT SATISFACTION ON TIME	PERCENTAGE OVERRUN ON COST	PERCENTAGE OVERRUN ON TIME
CLIENT SATISFACTION ON COST				
CLIENT SATISFACTION ON TIME	0.86 [3]			
PERCENTAGE OVERRUN ON COST	0.38 [1]	-0.35 [2]		
PERCENTAGE OVERRUN ON TIME	0.69	-0.76 [1]	-0.56 [3]	

1 - SIGNIFICANT AT $P < 0.10$.

2 - SIGNIFICANT AT $P < 0.05$.

3 - SIGNIFICANT AT $P < 0.01$

ALL OTHER CORRELATIONS
ARE NON SIGNIFICANT

FIGURE 17

McQUITTY ANALYSIS

The McQuitty analysis was used to examine the groupings and linkages between the variables in the model. The technique is applied to the full matrix of correlation coefficients (see appendix 5), and, by identifying the highest correlations, suggests the clustering of related variables. Starting with the highest correlations in the matrix, the related variables are identified cluster by cluster. This order of extraction represents a descending order of importance of variation that is likely to be explained by each cluster. Figure 18 gives the six clusters which have been identified, in order of extraction, together with the highest correlation between the clusters. The McQuitty analysis suggests the following conclusions:-

Firstly that time and cost are important, as shown in clusters 1 and 2. Both clusters relate to the concept of size and support the literature on the importance of this variable. Publicly funded clients build high cost, long term, large projects which tend to overrun the programmed time. The more costly projects have longer build times and are managed by integrated teams which use cost reimbursement procedures rather than competitive procedures (see the dotted line linkages).

Secondly that smaller projects of shorter build time are let under competition, and that design and construct results in shorter total time, (the dotted lines linking clusters 1 and 2).

Thirdly that high cost projects have higher build rates and a higher level of managerial control, (see the dotted lines linking cluster 2 and 5).

Fourthly there are only two strong pointers to project success, these are the level of managerial control and the total time of the project, (see dotted lines linking clusters 5 and 1).

Finally the variable of managerial control (in cluster 5), which is an important ingredient of success, should be grouped with the building team as one of its characteristics. The organisation of the building team therefore has an influence on project success, directly by virtue of the level of managerial control, and indirectly by influencing the total time of the project, (see the dotted lines connecting cluster 5 with clusters 4 and 1).

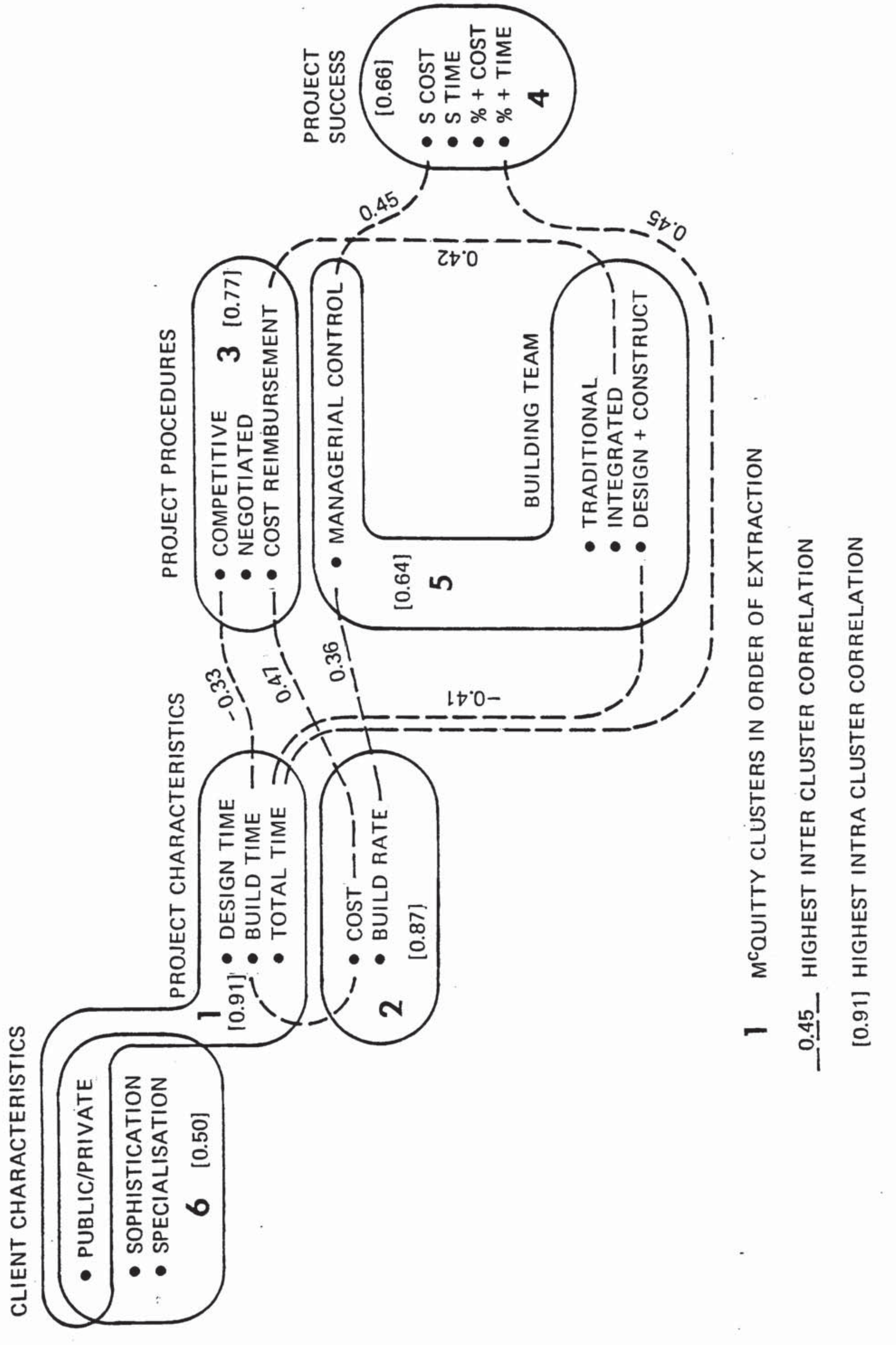

CLIENT CHARACTERISTICS
PUBLIC/PRIVATE
SOPHISTICATION
SPECIALISATION
6 [0.50]
PROJECT CHARACTERISTICS
DESIGN TIME
BUILD TIME
TOTAL TIME
1 [0.91]
COST
BUILD RATE
2 [0.87]
PROJECT PROCEDURES
COMPETITIVE
NEGOTIATED
COST REIMBURSEMENT
3 [0.77]
MANAGERIAL CONTROL
BUILDING TEAM
TRADITIONAL
INTEGRATED
DESIGN + CONSTRUCT
[0.64] 5
PROJECT SUCCESS
[0.66]
S COST
S TIME
% + COST
% + TIME
4
-0.33
0.47
0.36
-0.41
0.45
0.42
0.45
1 McQUITTY CLUSTERS IN ORDER OF EXTRACTION
0.45 HIGHEST INTER CLUSTER CORRELATION
[0.91] HIGHEST INTRA CLUSTER CORRELATION

FIGURE 18

MAIN CONCLUSIONS

The general hypothesis implicit in the research model is:-

> 'WHEN THE BUILDING TEAM AND PROJECT PROCEDURES ARE APPROPRIATE TO CLIENT AND PROJECT PROCEDURES, HIGHER LEVELS OF SUCCESS WILL BE ATTAINED.'

This was broken down into ten sets of main hypotheses, dealing with the clusters of variables labelled:-

client characteristics
project characteristics
project procedures
building team
project success

These ten main hypotheses were themselves broken down into 132 detailed sub-hypotheses which were expressed in the nul form and tested by the chi square test and correlation coefficient. The relationships of the 5 variables were diagrammed in the research model in figure 1 and reproduced with the results in figure 18. Five techniques were used for analysis of the results. Contingency tables were used to order the data and provide a basis for the measures of association, the chi square test and Pearson's correlation coefficient. The McQuitty analysis gave an indication of the grouping and linkages of the variables. Scattergrams were produced by computer, plotting relationships between all combinations of the variables, and were useful for identifying possible significant relationships for further analysis.

Client and project characteristics

Publicly funded clients build more costly projects, which take longer to design and build, and take longer overall. Publicly funded clients expressed a lower level of satisfaction on cost performance. Projects for publicly funded clients were more likely to overrun the budget and the programmed time than projects for privately funded clients.

On the other hand privately funded clients built lower cost projects and tended to be more specialised, that is, they may have built a similar project before. They expressed a higher level of satisfaction with performance on cost, and their projects were less likely to overrun on cost and time.

Interestingly the nul hypothesis was supported for the relationship between project cost and success, that is, the level of client satisfaction and the overrun on budget and time were independent of the cost of the project.

The project characteristics which do give an indication of the level of satisfaction and performance are build time, and total time, and possibly design time, though the association here may be less reliable (see figure 13).

Building team

It is commonly believed in the industry, and indeed it has been suggested by other researchers, that publicly funded clients are less willing than private clients to depart from the traditional organisation of the building team, and to adopt other forms such as design and construct. These results support this view (see figure 14).

Integrated teams, as opposed to non integrated teams, are used for higher cost projects. A possible reason for this is that clients building higher cost projects have repeat business and tend to form their own teams, or possibly that higher cost projects go to larger integrated practices. Whatever the reason it seems clear that integrated teams may have given a lower level of client satisfaction on time. But there is no evidence to suggest that integrated teams actually performed any worse than other teams. The larger projects tend to be more complex.

Design and construct teams were associated with projects of short build times and short total times. Since the total time is negatively associated with project success measures, it is perhaps not surprising that design and construct teams gave a higher level of client satisfaction on time. They were less likely to overrun the programmed time.

Project procedures

Projects which used competitive procedures were found to have shorter design times and total times than projects adopting non competitive procedures.

No direct relationship was found between client characteristics and project procedures. However projects with short design, build and total times were found, (figures 4 to 8), to be associated with privately funded clients and lower cost projects, so there may indeed be an indirect relationship between client characteristics and project procedures, as suggested by figure 18.

Integrated teams choose non-competitive procedures for appointing contractors. As integrated teams tend to be used on higher cost projects this also suggests that there might be a link between client characteristics and project procedures.

Managerial control (classed as a project procedure) was a key element in achieving project success, being significantly related to all of the measures of success. Higher levels of managerial control were associated with projects having high build rates. Traditional teams had lower levels of managerial control.

Success

There was close agreement among the success measures, and the subjective levels of satisfaction expressed by clients were in close accord with the actual performances on cost and time.

Time was more likely to overrun than cost. It is suggested that some clients may be less concerned with completion on time than adherence to the budget. Furthermore when delays occur it is very difficult to catch up, whereas expenditure may be controlled by variations to the contract.

Interpretation of the results

Bearing in mind the exploratory nature of this research, and the nature and size of the sample, the results indicate interesting relationships within the model of a reasonable level of significance. The McQuitty analysis is encouraging in that it supports most of the groupings suggested for the model.

A major difficulty however was the assessment of the variable concerned with the influence of the environment on every aspect of the building process. Chapter 1 discussed quite a range of possible ways in which the building process could be affected by environmental influences. Throughout the investigations, respondents were asked to mention any notable external influences, but no satisfactory means was found to compare their answers in quantitative terms. One project was delayed by a clearly definable period of seven weeks due to financial problems of the main contractor, however few influences could be so clearly expressed. Common complaints were concerned with shortages of materials and skilled labour, with the effects of inflation and the overheating of the economy experienced in the first half of the 1970's. Clients had difficulty obtaining satisfactory competitive tenders, although in the later part of the decade the level of competition was very keen. Some public sector clients had to hurry the project along to get it approved or completed before government restrictions were applied, and some clients lost part of their building programme. The results must therefore be interpreted with care, recognising the possibe importance of the unquantified environmental influences discussed in section 1.5.

The concept of the complexity of the project was discussed in chapter 1 and was explored during the first phase of eleven case studies, however no really satisfactory measure was identified. Complexity in purely technical terms is fairly easy to grasp as a concept, but the studies suggested that it was equally important to consider the complexity of the project as perceived by the individual members of the building team. One team might be able to handle a complex project with relative ease because of the level of experience and ability of its members whereas another, less experienced, team might do less well. The measure of build rate seemed to be a reasonable indication of the technical complexity of the project. It might be appropriate to consider the experience of the team in addition to this.

The question of value for money, or quality, was also explored in the first phase of the research, but this too proved difficult to assess. A number of clear answer is apparent. Since this question was not central to the thesis it was not pursued, the more objective measures of cost and time were used to indicate the level of success. It must be admitted, therefore, that there was probably a wide variation between the quality of the projects in the sample, independent of their stated level of success.

Following on from this, the more objective measures of cost and time also have their problems since there is no effective benchmark or scale to indicate how much a typical project should cost and how long it should take to build. To conclude that a particular organisational form achieves a higher success rate may only mean that it is able to pad out the estimate of cost and time to such an extent that the project is bound to be completed within budget and programmed time. One might argue that the reason publicly funded projects are more likely to overrun is that the budget and programme time are set by the client (or at least scrutinised by his advisers) and may therefore be more accurate, or perhaps optimistic. On the other hand privately funded clients may have less idea, (or different priorities) of how much the project should cost and how long it should take.

A final limitation which should be borne in mind is the complex and diverse nature of the industry which defies categorisation and precise definition. Building projects span many years and involve the efforts and contribution of many individuals, any one of whom could disrupt the entire project.

The next chapter, chapter 5, looks at a typical building process and simulates the operation of the model, in the light of the results.

CHAPTER 5 - MODEL SIMULATION

INTRODUCTION

This chapter illustrates the operation of the model using specific and comparative examples from the case studies. An algorithm is presented which expresses the relationships discovered between the variables within the model and provides the means by which the second principal objective of the research might be achieved, namely:-

> 'To develop a model to assist in the selection of building team and project procedures appropriate to client and project characteristics which will result in project success.'

PUBLICLY FUNDED PROJECTS

Figure 19 gives a composite profile for a publicly funded project. The relationships are taken from Appendix 6, for example publicly funded projects tend to cost more than £5m, have design times greater than 20 months, build times greater than 25 months, and total times greater than 50 months. They tend to use integrated teams and non competitive procedures. Most of these characteristics are likely to incur a low level of success on at least some of the success measures. Therefore such a project is likely to be unsuccessful overall. Some idea of the scale of the failure is gained by aggregating all the unsuccessful elements, this has been done in the diagram. Quite obviously there are more indicators of a low level of success and on balance such a project would be unsuccessful. The case studies themselves are given in appendix 1.

Figure 20 compares the profiles for two public projects. Case number 14 fits the profile exactly and is clearly unsuccessful, however case number 15 is very successful and the only difference, between the variables measured, is the type of building team which was used.

The relationships in Appendix 6 and the relationships in figure 19 clearly indicate that such publicly funded projects are likely to have a lower level of success. Case number 15 shows that this is not always true, the thesis underlying this research, and implicit in the model, would maintain that it was the influence of the moderator variable which made the difference in this case, ie. the adoption of the traditional building team instead of an integrated team. However one must always allow the influence of the environment, or other factors not measured.

PRIVATELY FUNDED PROJECTS

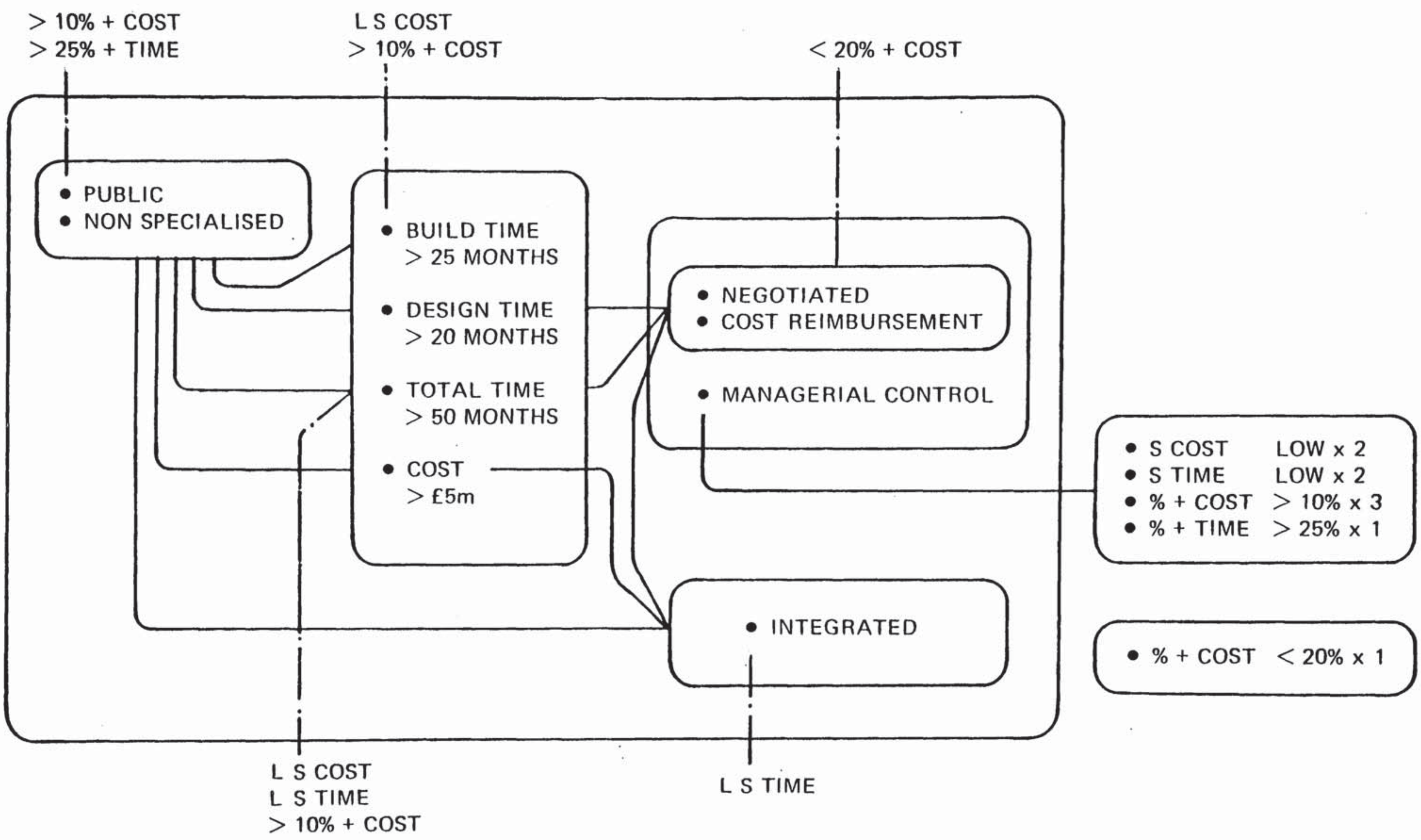
Figure 21 gives a typical profile for a privately funded project. The essential differences from publicly funded projects are the project characteristics which are lower cost, shorter design time, shorter build time, and shorter total time. Such projects use competitive procedures and traditional teams or design and construct with a higher level of managerial control.

Figure 22 compares the profiles of two private projects. Clearly case number 21 is unsuccessful and case number 20 successful in terms of overruns. The only difference being the level of managerial control.

SUMMARY

Analysis of the principal relationships as expressed in the two composite profiles for publicly funded and privately funded projects, with examples of successful and unsuccessful cases, shows that there are a number of determinants of success.

The client and project characteristics, as independent variables, may be important but not sufficient in themselves in determining ultimate project success. The moderator variables may act to bring success where failure would be expected. The moderator variables of project procedures, particularily the level of managerial control, and building team do seem to be able to convert unpromising circumstances into a successful outcome. The results presented do support the general hypothesis.



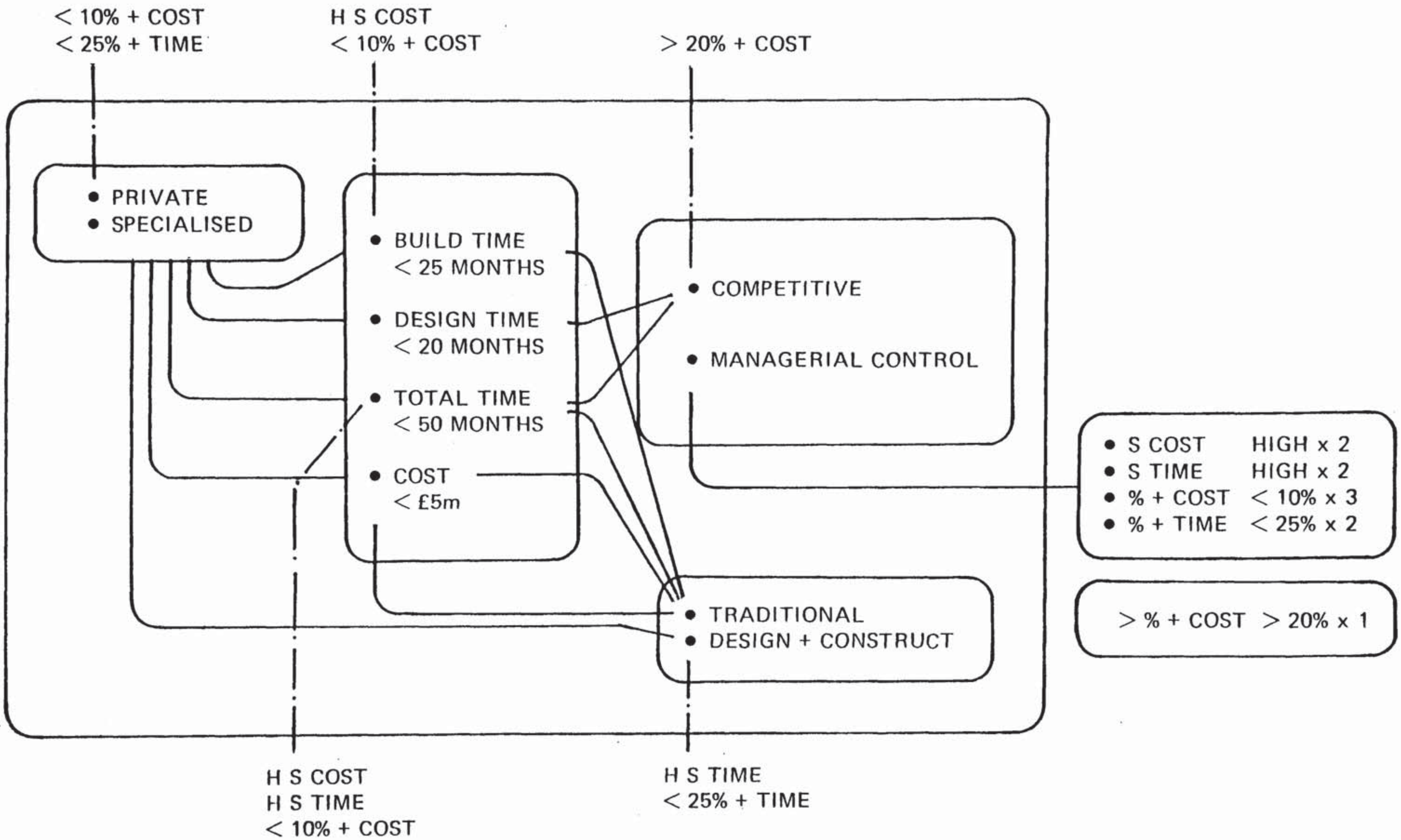
TYPICAL PROFILE FOR A PUBLICLY FUNDED CLIENT

FIGURE 19

EXAMPLE OF PUBLIC PROJECTS

VARIABLE MNEMONIC	TYPICAL PROFILE	CASE NO: 14	CASE NO: 15
CLIENT	PUBLIC	PUBLIC	PUBLIC
SOPHIS		HIGH	HIGH
SPECAL	LOW	MEDIUM	MEDIUM
COST	>£5M	£8.47M	£11.69M
DSTIME	>20MTHS	18MTHS	14MTHS
BLTIME	>25MTHS	43MTHS	33MTHS
TOTAL	>50MTHS	66MTHS	51MTHS
BLRATE		£197/MTH	£352/MTH
TRAD			TRAD
INTEG	INTEG	INTEG	
D+C			
COMPET		COMPET	COMPET
NEG	NEG		
REIMB	REIMB		
CONTRL	LOW	MEDIUM	MEDIUM
S COST	LOW	MEDIUM	HIGH
S TIME	LOW	LOW	HIGH
%+COST	>10%	21%	2%
%+TIME	>25%	59%	10%

FIGURE 20



TYPICAL PROFILE FOR A PRIVATELY FUNDED CLIENT

FIGURE 21

EXAMPLE OF PRIVATE PROJECTS

VARIABLE MNEMONIC	TYPICAL PROFILE	CASE NO: 21	CASE NO: 20
CLIENT	PRIVATE	PRIVATE	PRIVATE
SOPHIS	-	HIGH	HIGH
SPECAL	HIGH	MEDIUM	MEDIUM
COST	<£5M	£2.77M	£0.71M
DSTIME	<20MTHS	3MTHS	3MTHS
BLTIME	<25MTHS	11MTHS	6MTHS
TOTAL	<50MTHS	12MTHS	10MTHS
BLRATE	-	£252/MTH	£118/MTH
TRAD	TRAD	-	-
INTEG	-	-	-
D+C	D+C	D+C	D+C
COMPET	COMPET	COMPET	COMPET
NEG	-	-	-
REIMB	-	-	-
CONTRL	HIGH	MEDIUM	HIGH
S COST	HIGH	HIGH	HIGH
S TIME	HIGH	HIGH	HIGH
%+COST	<10%	25%	-0.25%
%+TIME	<25%	22%	-15%

FIGURE 22

THE MODEL AND ALGORITHM

The research model was developed to assist in the understanding of the variables in the building process and the relationships between these variables. It is meant to articulate the general hypothesis that it is possible to create an organisational form which would suit the independent variables of client and project characteristics.

Figure 23 is an algorithm of the variables which were found to be significant, their parameters and relationships. It shows for example that publicly funded clients build projects that cost more than £5m and that such projects have long design, build, and total times; that publicly funded clients use integrated teams and these tend to result in low success. Other relationships are shown, such as traditional team and design and construct which tend to use competitive procedures and have mixed results. Managerial control is a single variable which brings a high level of success.

Since the independent variables of client characteristics and project characteristics are influenced by the moderator variables there is no single best relationship which will result in a high level of success. However the research model may be used to select project procedures and a building team, with an appropriate level of managerial control, to match client and project characteristics, thereby creating an organisational form which has a good chance of achieving project success. The algorithm provides the criteria and parameters for this decision process.

Model simulation

For example:-

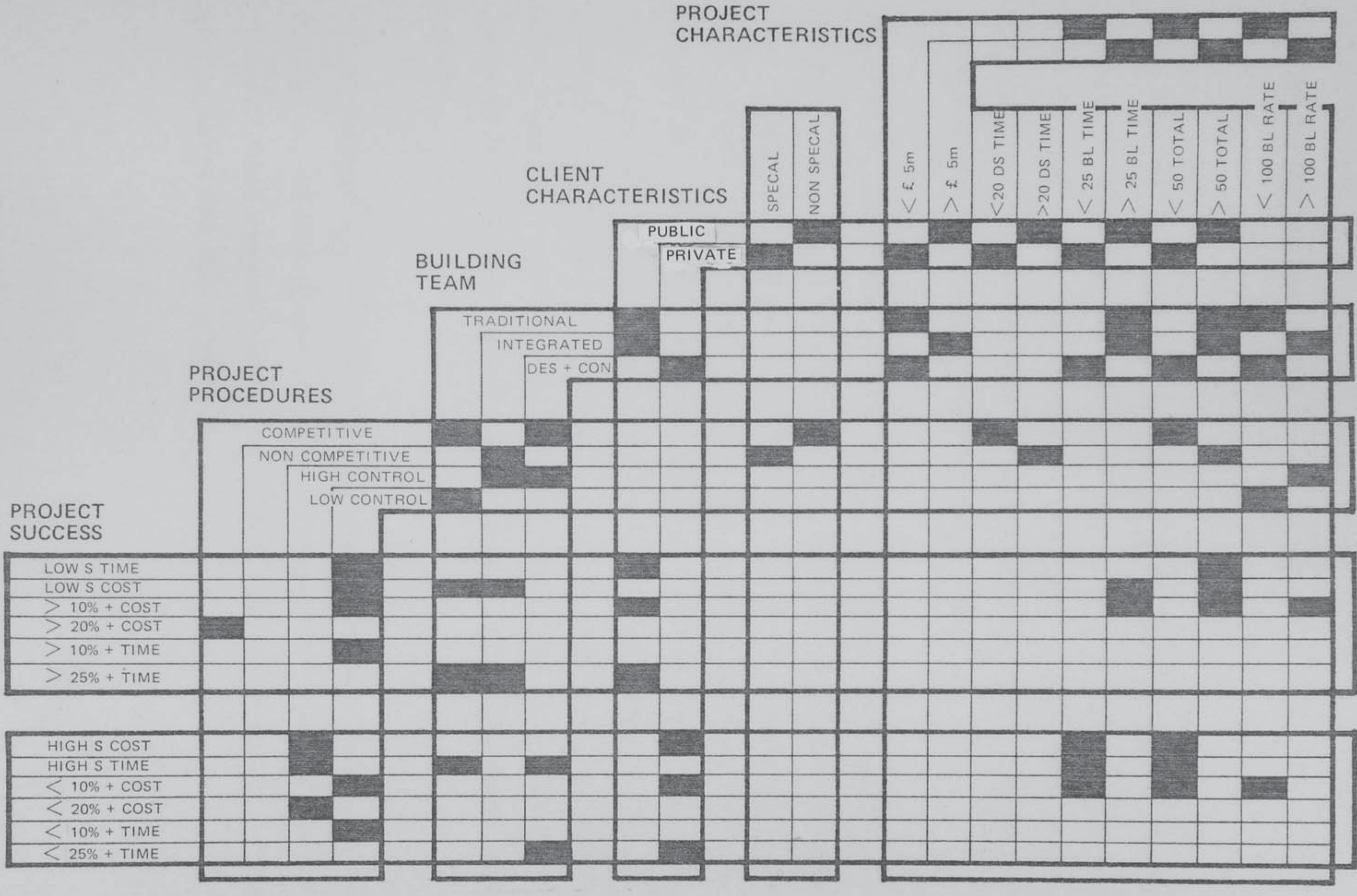
Suppose we have a public client wishing to build a project. The algorithm tells us that public clients tend to be non specialised and their projects cost more than £5m, taking more than 20 months to design, more than 25 months to build, and more than 50 months total time.

The algorithm indicates that such projects taking more than 25 months to build are likely to give a low level of client satisfaction on time, and are likely to exceed the budget by more than 10%.

If the project could be organised in some way so that the build time was less than 25 months then it would give a higher level of client satisfaction on time and would be less likely to exceed the budget. This could perhaps be done by sub-dividing it into phases, or by careful pre-planning. If the total time could be similarily reduced to less than 50 months then the algorithm indicates that a higher level of client satisfaction on time and cost could be achieved, and the project could be less likely to overrun the budget.

The algorithm also indicates that public clients tend to use traditional or integrated building teams, and there is a risk that these may result in a low level of satisfaction on cost, overrun on budget, and overrun on time. However when project procedures are taken into account, this likelihood of a low level of success can be mitigated by using non-competitive procedures, and particularly by adopting a high level of managerial control.

A similar example could be given for the privately funded clients. In addition to these two broad classifications the algorithm provides an indication of the implications of the characteristics of projects upon success and the consequences of adopting certain procedures.



AN ALGORITHM SHOWING VARIABLES WHICH CONTRIBUTE TO PROJECT SUCCESS

FIGURE 23

CHAPTER 6 - GENERAL CONCLUSIONS

Examination of the building process and identification of the principal variables in it has been the subject of this research. The construction industry must serve its clients to the best of its ability; the organisation of the building team and the way the team works through the building process is a central element of this service.

Organisation theory and systems theory have been found useful at a conceptual level, providing a framework for investigation of the process, identification of variables, and construction of the research model. The thesis implicit in the model is that the building process should be designed or adapted to fit the needs of the client and his project. Once these client and project characteristics have been identified then project procedures and building team should be chosen to complement these primary needs, creating an organisational form which should have a good chance of achieving a successful outcome to the project. The results support this concept.

Six main variables were identified and five were measured . The sixth, the environment, was seen to have influence on a number of the case studies but it was not found possible to construct suitable objective measures. Results were evaluated with this in mind.

General conclusions

The variables were measured for 32 cases and various tests were applied to the results. These indicate a number of relationships which support the thesis. Clearly some building teams and project procedures <u>are</u> more likely to provide a successful outcome to the project than others. The results show that the level of managerial control for the project is the single most important indicator of success. High cost projects (over £5m) take much longer to design and build and appear to achieve a lower level of success, in that clients are less satisfied, and such projects overrun more on time and cost. Publicly funded projects tend to cost more than £5m and privately funded projects less than £5m. Therefore it should be possible to adopt particular procedures and building teams in relation to client and project characteristics to improve the likelihood of satisfactory results.

The construction industry is very diversified, heterogeneous in structure, and complex in product type. These characteristics have a significant effect on the response of the building team, and the performance of the project. Many critics of the industry have pointed to its diversity and fragmentation and have argued that this induces problems (in communications, co-ordination, and control) which result in poor project performance. However, some have argued that this fragmentation is, in fact, an advantage and strength, because it provides flexibility and choice, and maintains competition and professionalism. Certainly a number of researchers have shown that problems of fragmentation, or differentiation, may be overcome by the adoption of particular procedures or integrative mechanisms. The results from this research support the argument that project success can be as readily achieved by traditional building teams as by fully integrated design and construct organisations. The key variable is the amount of managerial control, but the size of the project and other factors also have effect.

Therefore, as there are strong arguments for maintaining the current structure of the industry, what is apparently needed is more effective running and management of projects, particularily if they are large and complex. This supports the view expressed by other researchers that it is when projects become more complex in size or rate of construction that greater emphasis is needed on integration, or management and control of the project.

The research method

In the course of the research no major variables, acting on the building process, suggested themselves other than those studied. Indeed, many of the questions used during the first phase of the research were found to be of limited value, (see notes to the questionnaire in appendix 2). Considerable refinement of measurement technique allowed greater economy in the second phase of the study. Indices have been constructed for concepts, such as specialisation and control which are difficult to examine.

The area of research is complex, but this thesis has developed a methodology which is relatively straightforward and which, it is hoped, may be replicated by others. Further studies of different cases would be extremely valuable in building up a body of empirical knowledge concerning the subject.

APPENDIX 1 - CASE STUDIES

INTRODUCTION

This appendix contains brief details of the case studies. The first phase of eleven studies was conducted in 1977, and the second phase of 21 studies in 1978. They were done by means of structured interviews based on a questionnaire, study of contract documentation, drawings, correspondence, specifications, bills of quantities, etc., and site visits. In some cases data were gathered by correspondence where respondents were busy. A great deal of information and views were gathered from respondents, who were, without exception, very interested and concerned about the subject of the research. The data matrix in appendix 4 gives the results of each case study used for the analysis.

CASE STUDY 1

A 20 storey student residence block on a city centre site built for a university client. The traditional team included a very experienced architect and builder, however the client was relatively inexperienced. The contract was let on a two-stage tender and the contractor invited to propose alternative design solutions for the structural frame. The successful tenderer proposed a precast concrete panel system, however the Ronan Point collapse occurred at about that time, and, after a period of uncertainty, the contractor found he had to expend time and money to bring his system up to the new standard. Communications and relations between the members of the team were not good. The project was delayed and exceeded the budget.

CASE STUDY 2

This case was extremely interesting, 12 months into a 21 month contract the builder was forced into liquidation due to losses on other contracts. Such an event would normally stop all work, however the client had required the contractor to lodge a performance bond for 10% of the contract sum. Rather than forfeit this sum, the bank concerned preferred to put a receiver/manager in charge of this one project, retaining existing site staff. Apart from a short delay of seven weeks the project was completed satisfactorily. The building team was organised in a traditional manner with a professional architect, quantity surveyor, and builder, and the contract let by competition under the JCT form.

CASE STUDY 3

This case was the third similar block of university student residences, built for the same client by the same integrated design practice and a large national contractor. The keynote was the longstanding, harmonious relationship, that had been established, and the experience of all the parties. The building team was organised in the traditional manner and the tender negotiated on the basis of the previous phases. The project was completed satisfactorily.

CASE STUDY 4

This £8 million city centre office block was completed satisfactorily in four years under a design and construct contract. The client was a large public corporation with a continuous building need, and experience of design and construct contracts, having placed seven multi-million pound contracts prior to this. Three of these contracts were with the contractor involved with this case. The client had a system for handling and controlling such projects, derived from a clear brief and competition between two or three tenderers on a design and construct basis. Professional consultants were involved at all stages and the client had his own management team headed by an experienced project controller. This project was complex both in design solution and organisation.

CASE STUDY 5

An American manufacturing company with a world-wide annual turnover of $5 billion was the client for this large assembly plant. The building was a 42,000 square metre single storey factory, mainly of steel frame with precast concrete and troughed section steel cladding, built on a greenfield site. The client required the building as quickly as possible and let the building on a phased multi-bid basis with considerable fast tracking. The majority of the contract (75% by value) was let on a cost reimbursement plus fee basis under special contract conditions devised by the client. The rest of the contract was let by competition on the ICE conditions, for the civil engineering groundworks, and by direct purchase for the equipment. The client was very experienced, having built similar projects all over the world, the 80 man design team based in the USA was responsible for a capital building programme amounting to $2 million per day. Local design consultants, engineers, and quantity surveyors were employed and controlled by one of the client's project managers who was on site permanently.

CASE STUDY 6

Built in central London this was a luxury new office block for a borough council. Costing over £5 million the building had solar glass, air conditioning, recreation areas, restaurants and car parking. The council had a large building programme and was experienced in this type of work. The contract was let on competitive basis to a large national contractor. For some reason the project was unsuccessful, it was 1 year behind schedule and exceeded the budget. In searching for contributory factors it appeared that the client was under pressure to prepare documentation before a government cut-back in expenditure, and design problems may have contributed to the problems. There was also some overheating of the economy at that time and this might have raised problems for those concerned in construction.

CASE STUDY 7

This project was an amenity centre of traditional construction build by a local authority. The building team was organised traditionally and the contract let on a cost reimbursement basis to a national contractor. The completed building is particularily attractive and works well, but the project suffered considerable delays and exceeded the initial estimate by six hundred percent. There were some design problems which were not fully resolved before start on site, however the construction period spanned a period of rapid inflation which was not forseen at the time of the initial estimate. Being a cost reimbursement contract this extra cost was borne by the client.

CASE STUDY 8

This case study is related to case study 9 because it represents the first contract for a multi-storey local authority housing scheme which was determined after four years. The second contract is case 9. The project was first started in 1969, organised by a traditional team on a competitive contract for £5.35m, with a national contractor. Difficulties arose because of severe inflation, industrial problems on site, and the drawings and other documentation did not, in the contractor's view, truly reflect the complexity of the work. The contract was determined in 1973 having been idle for nearly two years, with only 40% of the work completed. At the end of the day it was generally conceded that the initial estimate of £5.35m was unrealistic considering the scope of the project, and that the period of inflation placed an untenable burden on the contractor.

CASE STUDY 9

This case was the second contract for the multi-storey housing scheme of case 8. The same design team placed a cost reimbursement fee contract with a large national contractor experienced with such contracts. Regular meetings were held on site with representitives of all concerned, particularly the client who thus became conscious of the need to make an effort and contribute to the running of the project. The new team had many problems to overcome, but did so very successfully, completing the project on time and within the revised budget of £12m. Of this sum only £3m was in fact paid on a cost reimbursement basis, the bulk of the work was subcontracted out by competitive tender.

CASE STUDY 10

This case was a speculative office block development and cost was of paramount importance. The budget represented a compromise of quantity and quality of accommodation, location and rental value. The initial scheme included air conditioning but the developer omitted it to achieve a saving of £100,000. The developer appointed a firm of letting agents as project managers, an architect, quantity surveyors, and the contract was let on a competitive basis to a small local contractor. A number of problems arose during the work, some design changes, changing requirements of pre-let areas, and the foundations were complicated due to the proximity of a railway tunnel beneath the building. There were over 130 variations to the contract, but overall the client was moderately satisfied with the job.

CASE STUDY 11

This project involved a group of buildings which were proposed during the building boom of 1970-1974 when the client experienced difficulty obtaining competitive tenders. Of twelve contractors invited to tender only two submitted tenders, a regional group associated with a national contractor was awarded the contract. Half way through the first project the client offered the remaining buildings as a serial contract, however relations became strained as the work proceded and the client became dissatisfied. The architect used his power under the JCT form of contract to require the replacement of the site management team, but the project was delayed by 18 months and exceeded the budget. The project was hit by the building strike of 1972, by the energy crisis and three day working week of 1974, and by industrial problems. Ultimately the negotiations for the completion of the serial failed and the consequent delay caused the publicly funded client to lose the buildings from his building programme due to expenditure cuts.

CASE STUDY 12

The client for this project was a large well known building society, requiring a new prestige head office located in a new industrial estate. Three design solutions were submitted by a design and construct company, an architectural practice, and an integrated design practice. The client chose the design proposed by the integrated practice. The five storey building was built to a high standard with an in-situ reinforced concrete frame, pre-cast concrete cladding, solar glass, and air conditioning. The contract was let by two stage competition to a large national contractor. The client did not need the building to be completed quickly, but, due to the installation of a computer, required the programme to be rigidly adhered to once set. The contractor was therefore asked to specify his own programme, and this was followed successfully.

CASE STUDY 13

This case was a contract to carry out substantial alterations to a building society office in a city centre. The building was single storey, of traditional construction with in-situ concrete frame. The building team was organised traditionally, the design and documentation being prepared by local professionals, and the contract let by selective competition to a local contractor. All the members of the team were experienced in the type of work and the project was completed on time and cost to the client's complete satisfaction.

CASE STUDY 14

An airport building was the subject of this case study, a £8m terminal extension to a major airport. The building was reinforced concrete with glass and metal cladding. It was a complex project with a high services element, including air conditioning and baggage handling equipment. The client had his own in-house design team experienced in this type of work. The contract was let competitively to a large multi-national contractor. The project suffered overrun on time and cost which was attributed to deficiencies in design documentation, co-ordination problems with services, a very tight programme, and labour problems on site.

CASE STUDY 15

This project was perhaps the most complex of those studied, it involved alterations to a major airport terminal, while the terminal remained in use. The project was designed and controlled by a traditional team headed by a private professional architectural practice, although the client did have in-house capability. The project was let competitively to a large multi-national contractor and was completed successfully practically on time and budget. The project had been well planned and the only problems that arose were concerned with the complex services element.

CASE STUDY 16

This case study was of extension and new work to an airport terminal building. The publicly funded client had his own in-house design team which handled the project, the construction work being let on a competitive basis to a large national contractor. The project was completed on time but exceeded the budget by 45%, due to variations in the contract works which were initiated by the client and accepted by him as being legitimate extensions to the contract. Accordingly the client expressed a high level of satisfaction with the project, regardless of the overrun on cost.

CASE STUDY 17

An industrial client required a straight forward envelope to his manufacturing process. The building was steel framed with profiled metal cladding, and was designed by the client's in-house design team which designs and controls the building of such standard industrial buildings for the company, throughout the UK. The contract was let competitively to a regional contractor. The client was completely satisfied with the project, although it would be fair to say that there was no particular concern, or brief, to produce an attractive building.

CASE STUDY 18

This was considered a prestige project; the client chose a professional architect in private practice instead of his own in-house team, and the project was let by competition to a local contractor. The project was not complex, being a fairly straight forward factory unit with office accommodation, however, a high standard was required by the client. The project was completed quickly, on time and on budget, despite delays during the design stage which forced a shorter construction programme onto the builder. The client expressed satisfaction, although he felt that the project cost was high.

CASE STUDY 19

This building was built for an industrial client and was a straightforward steel framed and clad envelope for his manufacturing process. The project was of standard design produced by the clients in-house team of designers and let competitively to a local contractor. Though rated as being highly successful, coming out 2% under the budget, the project was delayed for some time due to unforseen local problems.

CASE STUDY 20

Alterations to a branch office of one of the big five banks was the subject of this study. The client chose, under competition, a package deal company offering a 'management contractor service'. Close liason between the client and the management contractor during the design phase enable the project to be completed satisfactorily, without any variations, 4 weeks ahead of programme, and within the tight budget set. The redevelopment work was entirely traditional loadbearing cavity brick and block work with a pitched timber and slate roof.

CASE STUDY 21

This case was a new computer centre for a national bank in the west midlands. The construction of the building was straightforward, steel framed structure with precast concrete cladding, but with a high services element for the computer. The M & E contract for the computer installation was negotiated directly between the client and a specialist sub-contractor. The building contract was let under competition to a design and construct company and good co-operation existed between the parties. Though the contract exceeded the original programmed time this was due to additional work required by the client.

CASE STUDY 22

This project was a high rise city centre shop and office development in the midlands. The property developers were a banking group. A traditional professional team was used and the contract let under competition to a large contractor. The building was of traditional construction in reinforced concrete frame and cladding; it was of high quality and included air conditioning. Completion was delayed due to variations and materials shortages, and for some reason the development remained unlet for some time, though this was not necessarily the fault of the building team.

CASE STUDY 23

This project was a high rise office development by a banking group, built on a city centre site in the midlands. The building was of reinforced condrete frame with precast concrete cladding and was finished to a high quality, with air conditioning. The project was handled by a professional team under a traditional arrangement and the contract let under competition to a large contractor. The failure of one of the major sub-contractors to adhere to the programme caused delay to the contract and consequent dissatisfaction on the part of the client.

CASE STUDY 24

This rationalised traditional brick and timber project was a 500 unit barracks for the armed services. It was designed by an in-house team and let under competition to a large contractor. The project was completed within the budget, but there was a delay of twelve months on completion. This was due to delay on the part of the Ministry of Defence in supplying equipment, the three day working week in 1974 and its repercussions, and delays in the Gas board's programme of conversion to natural gas. The client also expressed reservations about the maintenance costs of the design solution, which included timber cladding.

CASE STUDY 25

This project was a military installation for the Ministry of Defence. Of traditional construction, it was designed by an in-house team and let under competition to a large contractor. Although not complex, the programmed time was exceeded and the budget exceeded by a considerable amount. The client felt that this was due to factors outside the control of the building team, the three day working week in 1974, and a shortage of skilled bricklayers. The overrun on the budget was partly due to variations and price fluctuations.

CASE STUDY 26

The client considered this a very successful project. It was a military installation for the Ministry of Defence, and though the client had his own in-house design team this project was designed by an outside team in a traditional manner. The building was of traditional construction and let under competition to a large contractor. The client reported good all round liason between the members of the team, the budget was exceeded because of fluctuations in prices and minor contract delays.

CASE STUDY 27

This project was a military installation for the Ministry of Defence. It was required urgently and though the client had his own in-house design team it was decided to let the project on a design and construct basis to expedite the work. The initial commission was let on the basis of preliminaries, performance specification, and sketch drawings. The contractor completed the building, which was of traditional construction, within only 17 months. The client was very pleased with the project, though expressed the opinion that it had been a relatively expensive solution.

CASE STUDY 28

This case study was of a four phase project for a complex of warehouse blocks built for a pharmaceutical manufacturing company in south London. The project was built by a design and construct company, appointed by negotiation. The buildings were of traditional steel frame, with brick cladding and an asbestos cement sheeted roof. The design and construction times for the four phases overlapped and so they were treated as one project, taking the extreme project dates. The contractor was particularily experienced in this type of work and a high level of satisfaction was expressed by the client.

CASE STUDY 29

This project was a fairly complex laboratory, built of in-situ reinforced concrete frame with brick cladding and a high services element. The project was built for a pharmaceutical firm, and was designed by a professional team in the traditional manner and let under competition to a large national contractor. The project was delayed by six months (24% overrun), and this was attributed to the collapse of a principal sub-contractor. The budget was exceeded but the client recognised that this was compatible with inflation and felt that the contractor had performed as well as could be expected under the circumstances.

CASE STUDY 30

This case was a laboratory built for a pharmaceutical manufacturing company in south London. The project was handled by a traditional professional team, and the construction let by competitive tender to a large contractor. The building was of traditional insitu reinforced concrete frame with brick cladding. The client expressed complete satisfaction with this project, which was completed on time and within budget.

CASE STUDY 31

This high rise project was a student residence block for a university client, and was built on a city centre site. The client had previously built a similar residence block under a traditional arrangement, and now felt confident enough to prepare a detailed specification and to let the contract, competitively, on a design and construct basis. The tender was evaluated by a firm of professional quantity surveyors and was let to a large national contractor. It was essentially a precast concrete system built structure with brick cladding. The project was completed on time and within budget, and the client expressed complete satisfaction.

CASE STUDY 32

This high rise project was a student residence block for a university client, and was built on a city centre site. The contract was let, competitively, on a design and construct basis. The design solution proposed by the succesful contractor was of an in-situ reinforced concrete central service core constructed by continuous pour, the remainder of the structure being of insitu reinforced concrete with brick cladding. Performance was good, but a delay of 4 months was incurred during construction of the central core due to problems with the sliding shutter. The client was satisfied with the project.

APPENDIX 2 - THE QUESTIONNAIRE

INTRODUCTION

The interviews were conducted in two phases, the first phase in 1977, of eleven case studies, was an extensive study involving meetings with the client, architect, quantity surveyor, and contractor. Data were also gathered from study of contract documentation, correspondence, drawings, specification, and by site visit. A great deal of data were gathered, and much background information. This first phase thoroughly explored the variables proposed in the model and as a result of experience the questionnaire for the second phase was modified to be more efficient and fewer questions were asked. Experience on the first phase showed complete agreement between the respondents, for the subject areas of the questions, and during the second phase the client was the principal source of the information. The second phase, of 21 case studies, was conducted during 1978, with the assistance of a research student, (Coomber 1978).

QUESTIONNAIRE ON BUILDING TEAM ORGANISATION PATTERNS - 1977

Project details

A1 Brief description of project, (location, type, etc.):
A2 Contract value, (budget and final account etc.):
A3 Project start (ie. brief) date:
A4 Construction start date:
A5 Construction finish date:
A6 Members of the project team:
(client, architect, q.s., engineer, contractor):

Interviewee details

date:

B1 Interviewee name/title:
B2 Details of interviewee's firm:
(size, contribution to team,
experience, type of projects
built before etc.)
B3 Role of interviewee in project:
(include dates or period involved, contribution)
B4 Interviewee to draw his impression of the pattern
of organisation of the team (separate sheet):
B5 Collect set of project drawings:
B6 Collect specification, BCIS analysis, contract form:

CLIENT CHARACTERISTICS   COMPLEXITY OF BUILDING No:1.01

encircle appropriate rank

Technologically complex:	1
'one off' buildings such as hospitals, complex office blocks, university laboratories etc.	2
Standard complex: buildings which are complex in nature but have a certain element of standardisation that can be repeated on other jobs, eg. telephone exchanges, industrial buildings, schools.	3
Complex repetitive	4
buildings which are complex to a degree but the complex elements are repeated floor by floor, eg. blocks of flats, hotels, university residences.	5
Simple buildings:	6
traditional housing, straightforward factories and warehouses etc.	7

Note:
The first phase found that this was an extremely difficult variable to assess, the build rate (ratio of cost divided by build time) seemed to provide just as good an indication. This subjective measure was not included in the second phase.

PRICE No:1.02

encircle appropriate rank

Vital:	1
price is critical and the lowest price must be obtained	2
Very important:	
price must be related to yardsticks or norms and should therefore be within those limits	3
Fairly important:	4
the client is interested in overall quality of the design solution and price is secondplace.	5
Little importance:	6
the most important consideration may be time, for example, or another factor and under these conditions price is relatively unimportant	7

<u>Note:</u>
Respondents found difficulty in expressing their priorities for cost and time, and this did not seem to have any bearing on the performance of the project. Neither of these variables was explored in the second phase.

PROJECT TIME No:1.03

encircle appropriate rank

Vital:	1
contract time is critical and must be attained in the shortest possible time from inception to completion, at the expense of other factors.	2
Very important: construction should be completed in the shortest within reasonable price limits	3
Fairly important: completion by a specific date required, perhaps to coincide with term dates, or accounting periods for schools, shops, factories, etc. If the project runs late	4
then this may become critical.	5
Little importance:	6
when completion time is unimportant and other factors may be more pressing	7

<u>Note:</u>
Respondents found difficulty in expressing their priorities for cost and time, and this did not seem to have any bearing on the performance of the project. Neither of these variables was explored in the second phase.

CLIENT INVOLVEMENT No:1.04

encircle appropriate rank

Close involvement:	1
client has complex requirements perhaps not finalised and therefore needs close and detailed contact throughout the process. May have his own design group working closely with the building team	2
Moderate involvement:	
involvement in some decisions, some meetings with the design team, and the contractor.	3
Monitoring only:	4
the client only requires involvement to the extent of monitoring and approving progress and payments.	5
No involvement:	6
client does not wish to be involved at all after initial agreement of objectives and cost limits.	7

Note:

Experience during one case study suggested that this variable and the next variable, client procedures, might be important. However this was not apparent from subsequent studies and the variables were abandoned.

CLIENT PROCEDURES No:1.05

encircle appropriate rank

Complex procedures: the client organisation has a complex situation involving external and internal procedures such as yardsticks, board level approval, inter-departmental liason.	1
	2
	3
Fairly complicated: involving perhaps only internal approval and monitoring of decisions and occasional meetings.	4
	5
Simple situation: perhaps dealing with only one individual client, or representative, who has autonomy and authority to make decisions without reference to others.	6
	7

Note:

Experience during one case study suggested that this variable might be important. However this was not apparent from subsequent studies and the variables were abandoned.

PROJECT PROCEDURES No:2.00

encircle appropriate rank

Rigid system (risk bearing): such as open competition, selective tendering, serial tendering.	1
	2
	3
Negotiated competitive (risk bearing): for example two stage tendering, approximate quantities, schedule of rates, etc.	4
	5
Cost reimbursement (non risk bearing): fully negotiated contracts, fee contracts, etc.	6
	7

Note:
During data collection it was apparent that respondents were quite clear about the classification of project procedures into three types, competitive (rigid system above), negotiated (as above), and cost reimbursement (as above). Therefore there was no need, or possibility, of ranking on a seven point scale.

PROJECT TEAM ORGANISATION No:3.00

encircle appropriate rank

Fragmented pattern:	1
involving the use of professionals working from separate practices in a traditional manner. Though there is a degree of flexibility possible; in principle the system is fairly rigid conforming to accepted practices and procedures.	2
	3
Partially integrated pattern:	
the systems used in this sub division afford a great deal more flexibility and generally provide a wide range of alternatives to the client in terms of services; time scale, procedures etc.	4
	5
Fully integrated systems:	6
representing a system where all services are provided by one body, eg. all design quantification, construction, etc. within an organisation such as a local authority or package deal firm.	7

Note:

As was the case with project procedures, during data collection respondents were quite clear that the patterns were either traditional (fragmented above), integrated (partially integrated above), or design and construct (fully integrated above). Consequently these terms were used during the second phase and in the analysis.

CONTROL MECHANISMS No:4.00

encircle appropriate rank

FACTORS: LOW SCORE = FEW OF THESE FACTORS PRESENT
HIGH SCORE = MANY OF THESE FACTORS PRESENT

1. The initial capital cost (tender price) must represent value for money, price vs. quality.	1
2. Suitability and optimisation of the initial design solution having regard to the clients requirements	2 3
3. The appropriateness of the building as regards costs in use	4 5
4. The maintenance of standards and value for money during the construction phase, ie. adherence to quoted terms, and interpretetion of quality, payments and control	6 7

Note:

Results for the first phase suggested that respondents considered most projects had all four of these control mechanisms, only one or two projects were given a low score on this scale. They saw the presence of an element of managerial control as having significant influence on the control mechanisms. Therefore a three point rating was adopted for the second phase in which a high score was given where the project had distinct element of managerial control, additional to the four factors above.

PROJECT SUCCESS No:5.00

LOW 1 2 3 4 5 6 7 HIGH......................SCORE

5.01 Is the building basically fit for the purpose, does it satisfy the clients needs..................................

5.02 Does the building represent value for money overall.............................

5.03 Was the project built on time.......................

5.04 Is the project aesthetically satisfactory...

5.05 Life cycle costs, will the running and maintenance costs be high or low......................................

5.06 Were relations between the members of the project team good or bad..

Note:
Respondents found difficulty in answering these questions and only the subjective opinions on satisfaction on cost and time were utilised and measured in the second phase.

QUESTIONNAIRE ON BUILDING TEAM ORGANISATION PATTERNS-1978

Project details

1 Brief description of project,
  (location, type of construction etc.):
2 Contract cost - budget:
3 - final account:
4 Project times - design start:
5 - design complete:
6 - construction start:

Client details

7 Name and general details of client:
8 Public or privately funded:
9 Experience and specialisation
  (Number & type of projects built before)

Project procedures

10 Form of contract:
11 competitive/negotiated/cost reimbursement:
12 Control: high; medium; low

Organisational form

13 (A) - Traditional/fragmented pattern
14 (B) - Integrated team of professionals
15 (C) - Composite main contractor with all sub-trades and suppliers.
16 (D) - Client with own design team in-house
17 (E) - Client with own design team and own construction firm in-house
18 (F) - Contractor offering design and construct a 'package deal'
19 (G) - Consortium of designers and builders offering a complete, but independant service.
20 (H) - Client, designers, and builder all in one company, eg. developer.

Project success

21 Level of satisfaction on cost:
22 Level of satisfaction on time:
23 Level of satisfaction on design:
24 Level of satisfaction on overall performance:

25 Reasons for success or failure:
26 General comments:

APPENDIX 3 - SCORING SCHEME

Some of the questions in the first phase proved difficult to measure and evaluate and, after some preliminary exploratory analysis, were not included in the final results. The second phase questionnaire did not include these questions.

Client characteristics.

Clients (CLIENT), were categorised as either funded from public funds (PU), or from private funds (PR). Publicly funded clients were given the numeral 0, and privately funded clients the numeral 1, for correlation purposes.

Clients were scored on the two variables of sophistication (SOPHIS) and specialisation (SPECAL) on the basis of their previous building experience. Those with no previous experience were given a score of L (or 1). Those with some previous experience were given a score of M (or 2), and those who had considerable experience were given a score of H (or 3). The scale of sophistication related to general experience of building, and the scale of specialisation related to specific experience of building projects of the type in the individual case study.

Project characteristics

The variable project cost (COST), was scored as the actual final account value for the project, adjusted to the common base year of 1975 (second quarter) in accordance with the current index of the cost of new construction as published in the Housing and Construction Statistics. This year was chosen as the base because it was in the middle of the spread of contracts and therefore involved the minimum of adjustment to the figures.

The design time (DSTIME), building time (BLTIME), and total time (TOTAL), were the actual durations expressed in numbers of months. The total time was the time from start of design to completion of the building, and does not therefore always equal the summation of design time and build time where there was design/build overlap.

The building rate (BLRATE), was scored as the cost in pounds (as adjusted to base year) divided by the building time and expressed as a figure. It represents the average turnover per month for the project and is given in terms of 1000£ per month.

Organisational form

The organisational form was divided into three types which were, the traditional team (TRAD), the integrated team (INTEG), and design and construct (D+C). In the second phase, although the questionnaire included eight possible forms, only forms designated A (TRAD), D (INTEG), and F (D+C) were encountered. Their occurrence in the data matrix was indicated by T, I, or DC (or the number 1 for correlation purposes).

Project procedures

Project procedures were of three types, competitive procedures (COMPET), negotiation (NEG), and cost reimbursement (REIMB). Their occurence in the data matrix was indicated by C, N, or R. The variable managerial control (CONTRL), was graded however, and this was scored L (or 1) where the degree of control was low, scored M (or 2) where the degree of control was average, and scored H (or 3) where there was a high degree of control.

Success Measures

The two subjective measures of client satisfaction on cost (SCOST), and time (STIME) were each scored L (or 1), where there was a low level of satisfaction. Scored M (or 2), where there was a reasonable level of satisfaction, and H (or 3), where there was a high level of satisfaction.

The two more objective measures of percentage overrun on programmed time (%+TIME), and percentage overrun on budget (%+COST), were expressed as the actual percentage of the amount by which the budget or programme was exceeded.

APPENDIX 4 - MATRIX OF RESULTS

CASE STUDY NUMBER

	1	2	3	4	5	6	7	8
CLIENT	PU	PU	PU	PU	PR	PU	PU	PU
SOPHIS	L	M	H	H	H	M	M	M
SPECAL	L	M	M	M	H	M	M	M
COST	1.32	0.59	0.54	8.31	11.09	5.41	1.96	5.35
DSTIME	17	45	28	7	8	48	36	85
BLTIME	25	21	18	46	23	42	33	45
TOTAL	42	66	46	53	31	90	69	130
BLRATE	53	28	30	181	462	129	59	134
TRAD	T	T				T		T
INTEG			I		I		I	
D+C				DC				
COMPET	C	C				C		C
NEG			N	N				
REIMB					R		R	
CONTRL	L	M	M	H	H	M	M	L
SCOST	L	H	H	H	H	M	L	L
STIME	M	H	H	H	H	L	L	L
%+COST	-0.5	0	0	0	0	16	19	114
%+TIME	32	8	0	0	25	19	36	89

For explanation of codes see appendix 3

Appendix 4 - matrix of results

CASE STUDY NUMBER

	9	10	11	12	13	14	15	16
CLIENT	PU	PR	PU	PR	PR	PU	PU	PU
SOPHIS	M	H	H	M	M	H	H	H
SPECAL	M	M	M	M	M	M	M	M
COST	12.63	0.63	1.95	3.40	0.16	8.47	11.63	6.76
DSTIME	84	49	24	17	5	18	14	12
BLTIME	48	24	43	24	12	43	33	38
TOTAL	132	73	67	41	17	66	51	53
BLRATE	263	26	46	142	13	197	352	178
TRAD		T			T		T	
INTEG	I		I	I		I		I
D+C								
COMPET		C		C	C	C	C	C
NEG			N					
REIMB	R							
CONTRL	H	L	M	H	M	M	M	M
SCOST	H	H	L	H	H	M	H	H
STIME	H	M	L	H	H	L	H	H
%+COST	0	0	2	0	-2	21	2	45
%+TIME	0	0	75	0	0	59	10	0

For explanation of codes see appendix 3

Appendix 4 - matrix of results

CASE STUDY NUMBER

	17	18	19	20	21	22	23	24
CLIENT	PR	PR	PR	PR	PR	PR	PR	PU
SOPHIS	H	H	H	H	H	H	H	H
SPECAL	H	H	M	M	M	M	M	M
COST	5.25	0.38	0.52	0.71	2.77	2.39	4.00	3.24
DSTIME	8	6	6	3	3	9	6	51
BLTIME	19	10	21	6	11	41	29	41
TOTAL	22	15	23	10	12	55	38	82
BLRATE	276	38	25	118	252	58	138	79
TRAD		T				T	T	
INTEG	I		I					I
D+C				DC	DC			
COMPET	C	C	C	C	C	C	C	C
NEG								
REIMB								
CONTRL	M	M	H	H	M	M	M	M
SCOST	H	M	H	H	H	H	M	M
STIME	H	M	L	H	H	M	M	L
%+COST	3	0	-2	-0.25	25	0.5	52	25
%+TIME	12	0	31	-15	22	17	21	47

For explanation of codes see appendix 3

Appendix 4 - matrix of results

CASE STUDY NUMBER

	25	26	27	28	29	30	31	32
CLIENT	PU	PU	PU	PR	PR	PR	PR	PR
SOPHIS	H	H	H	H	H	H	M	M
SPECAL	M	M	M	H	H	H	M	M
COST	1.17	1.01	0.71	1.03	1.68	1.07	0.91	1.21
DSTIME	34	17	12	42	17	17	2	5
BLTIME	35	23	17	46	31	25	19	22
TOTAL	71	45	17	49	54	47	25	32
BLRATE	33	44	42	22	54	43	48	55
TRAD		T			T	T		
INTEG	I							
D+C			DC	DC			DC	DC
COMPET	C	C	C				C	C
NEG				N	N	N		
REIMB								
CONTRL	M	M	M	M	M	M	M	M
SCOST	H	H	M	H	H	H	H	H
STIME	M	H.	H	H	M	M	H	L
%+COST	73	8	15	0	1	10	-5	0.25
%+TIME	35	10	13	2	24	19	0	22

For explanation of codes see appendix 3

APPENDIX 5 - CORRELATION COEFFICIENTS

PEARSONS CORRELATION COEFFICIENT

	CLIENT	SOPHIS	SPECAL	COST	DSTIME	BLTIME	TOTAL
CLIENT	1.00						
SOPHIS	0.17	1.00					
SPECAL	0.50	0.49	1.00				
COST	-0.30	0.05	0.05	1.00			
DSTIME	-0.47	-0.29	-0.11	0.22	1.00		
BLTIME	-0.50	-0.01	-0.08	0.50	0.57	1.00	
TOTAL	-0.57	-0.25	-0.19	0.41	0.91	0.78	1.00
BLRATE	-0.02	0.15	0.18	0.87	-0.05	0.13	0.05
TRAD	0.06	-0.18	-0.00	-0.15	0.11	-0.06	0.14
INTEG	-0.26	0.14	0.02	0.30	0.15	0.24	0.21
D+C	0.23	0.06	-0.02	-0.17	-0.30	-0.21	-0.41
COMPET	0.07	-0.14	-0.41	-0.19	-0.18	-0.33	-0.22
NEG	0.00	0.31	0.37	-0.13	-0.01	0.25	0.03
REIMB	-0.11	-0.19	0.13	0.47	0.29	0.17	0.29
CONTRL	0.18	0.23	0.21	0.33	-0.26	-0.06	-0.22
SCOST	0.44	0.35	0.32	0.05	-0.29	-0.28	-0.32
STIME	0.20	0.08	0.14	0.11	-0.30	-0.40	-0.42
%+COST	-0.32	0.01	-0.14	0.11	0.41	0.33	0.45
%+TIME	-0.35	-0.07	-0.14	0.09	0.33	0.45	0.45

Appendix 5 - correlation coefficients

PEARSONS CORRELATION COEFFICIENT

	BLRATE	TRAD	INTEG	D+C	COMPET	NEG	REIMB
CLIENT							
SOPHIS							
SPECAL							
COST							
DSTIME							
BLTIME							
TOTAL							
BLRATE	1.00						
TRAD	-0.21	1.00					
INTEG	0.26	-0.64	1.00				
D+C	-0.05	-0.44	-0.41	1.00			
COMPET	-0.09	0.23	-0.23	-0.01	1.00		
NEG	-0.23	-0.07	0.04	0.13	-0.77	1.00	
REIMB	0.45	-0.27	0.42	-0.17	-0.51	-0.15	1.00
CONTRL	0.36	-0.51	0.36	0.19	-0.29	0.07	0.35
SCOST	0.16	-0.12	-0.07	0.22	0.01	0.07	-0.10
STIME	0.28	-0.13	-0.19	0.38	-0.04	0.03	0.02
%+COST	0.04	0.07	0.07	-0.17	0.24	-0.21	-0.09
%+TIME	0.00	-0.00	0.26	- 0.30	-0.03	0.02	0.02

PEARSONS CORRELATION COEFFICIENT

	CONTRL	SCOST	STIME	%+COST	%+TIME
CLIENT					
SOPHIS					
SPECAL					
COST					
DSTIME					
BLTIME					
TOTAL					
BLRATE					
TRAD					
INTEG					
D+C					
COMPET					
NEG					
REIMB					
CONTRL	1.00				
SCOST	0.45	1.00			
STIME	0.31	0.66	1.00		
%+COST	-0.37	-0.38	-0.35	1.00	
%+TIME	-0.36	-0.69	-0.76	- 0.56	1.00

APPENDIX 6 - CHI SQUARE TEST RESULTS

RELATIONSHIP	CHI SQ	PROBABILITY
Client characteristics		
1. Private clients more specialised than public clients, dichotomised at (L&M) vs. H.	7.38	p<0.01 *
2. Public projects more costly than private, dichotomised at £5m.	5.62	p<0.025
3. More specialised clients use non competitive procedures, dichotomised at (L&M) vs. H.	3.78	p<0.1
4. Public projects have longer design times, dichotomised at 20 months.	8.92	p<0.01
5. Public projects have longer build time, dichotomised at 25 months.	4.55	p<0.05
6. Public projects have longer total time, dichotomised at 50 months.	12.59	p<0.001
Project characteristics		
7. Projects costing over £5m take longer to build, dichotomised at 25 months.	3.73	p<0.1
8. Projects costing over £5m take longer total time, dichotomised at 50 months.	3.73	p<0.1
9. Projects costing over £5m have higher build rates, dichotomised at 120£/month.	24.57	p<0.001*
Building team		
10. Public clients are less likely to use design and construct than private clients.	2.97	p<0.1
11. Integrated teams, as opposed to non integrated teams, are used on higher cost projects, dichotomised at £5m.	2.73	p<0.1

* denotes presence of cell value of 0

RELATIONSHIP	CHI SQ	PROBABILITY
12. Integrated teams, as opposed to non integrated teams, are used on projects with higher build rates dichotomised at 150£/month.	2.84	$p<0.1$
13. Design and construct, as opposed to other teams, has shorter build times, dichotomised at 20 months.	3.67	$p<0.1$
14. Design and construct, as opposed to other teams, has shorter total times, dichotomised at 40 months.	7.86	$p<0.01$
15. Traditional, as opposed to non traditional teams, has lower level of control, dichotomised (L&M) vs. H.	3.63	$p<0.1$*
Project procedures		
16. Competitive, rather than non competitive, procedures give shorter design times, dichotomised at 20 months.	2.76	$p<0.1$
17. Competitive, rather than non competitive, procedures give shorter total times, dichotomised at 40 months.	2.76	$p<0.1$
18. Competitive, rather than non competitive, procedures are used by non integrated teams, as opposed to integrated teams.	2.73	$p<0.1$
19. A higher level of managerial control is associated with projects having higher build rates dichotomised at (L&M) vs. H and 100£/month.	8.12	$p<0.01$
PROJECT SUCCESS MEASURES		
Client characteristics		
20. Private clients expressed a higher level of satisfaction on cost dichotomised at (L&M) vs. H.	5.24	$p<0.025$

* denotes presence of cell value of 0

RELATIONSHIP	CHI SQ	PROBABILITY
21. Projects for public clients overrun the budget more than projects for private clients, dichotomised at 10% overrun.	5.02	$p<0.025$
22. Projects for public clients overrun programme time more than projects for private clients, dichotomised at 25% overrun.	5.62	$p<0.025$
Project characteristics		
23. Projects with shorter build times gave higher client satisfaction on time, dichotomised at 25 months and (L&M) vs. H.	4.59	$p<0.1$
24. Projects with shorter build times overran less on cost, dichotomised at 25 months and 10%.	5.25	$p<0.025$
25. Projects with shorter total times gave higher client satisfaction on cost, dichotomised at 60 months and (L&M) vs. H.	6.17	$p<0.025$
26. Projects with shorter total times gave higher client satisfaction on time, dichotomised at 60 months and (L&M) vs. H.	5.24	$p<0.025$
27. Projects with shorter total times overran less on cost, dichotomised at 60 months and 10%.	6.17	$p<0.025$
28. Projects with lower build rates overran less on cost, dichotomised at 40£/month and 10%.	5.44	$p<0.025$
Building team		
29. Integrated, rather than non integrated, teams gave less client satisfaction on time, dichotomised at (L&M) vs. H.	3.03	$p<0.01$
30. Design and construct, as opposed to other teams, gave higher client satisfaction on time, dichotomised at (L&M) vs. H.	6.69	$p<0.01$

RELATIONSHIP	:CHI SQ	:PROBABILITY
31.Design and construct, as opposed to other teams, overran less on time, dichotomised at 25%.	: 3.68 :	$p<0.1$
Project procedures		
32.Non competitive, as opposed to competitive, procedures overran less on cost, dichotomised at 20%.	: 2.82 :	$p<0.1$
33.A higher level of managerial control gave higher client satisfaction on cost, dichotomised at (L&M) vs. H.	: 3.72 :	$p<0.1$
34.A higher level of managerial control gave higher client satisfaction on time, dichotomised at (L&M) vs. H.	: 3.28 :	$p<0.1$
35.A higher level of managerial control overran less on cost, dichotomised at (L&M) vs. H and 10%.	: 7.39 :	$p<0.01$
36.A higher level of managerial control overran less on time, dichotomised at (L&M) vs. H and 10%.	: 3.72 :	$p<0.1$
Relationship between success measures		
37.The level of client satisfaction on cost is directly linked with client satisfaction on time.	:15.60 :	$p<0.01$
38.The level of client satisfaction on cost is directly linked with percentage overrun on cost.	: 5.31 :	$p<0.1$
39.The level of client satisfaction on time is directly linked with percentage overrun on cost.	: 6.70 :	$p<0.05$
40.The level of client satisfaction on time is directly linked with percentage overrun on time.	: 5.92 :	$p<0.1$
41.The level of percentage overun on cost is directly linked with percentage overrun on time.	:19.50 :	$p<0.001$

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ACKNOWLEDGEMENTS

I would like to express my sincere thanks to my supervisors, Professor W B Jepson, and Dr D Pheysey for their help and guidance in my research.

I would also like to express my gratitude to the many people in the industry who gave so much of their time and expertise in assisting me with the research.

A C Sidwell

April 1982.