PROJECT MANAGEMENT FOR THE CONSTRUCTION INDUSTRY: AN EXAMINATION OF A SYSTEMS APPROACH

Thomas A Moore and David R Moore

De Montfort University, Department of Building Studies, The Gateway, Leicester,LE1 9BH, UK

This paper focuses upon the effects of environmental sub-systems on a described hypothetical construction project. An evaluation model is applied to the project and examines the manner in which subsystems within the project determine the extent of openness required by an organisation structure suitable for the project. Construction projects in general must have a high degree of openness due to the need to respond to a range of environmental forces which are external to the project. From this position the paper suggests that organisation structure design for construction projects should emphasise flexibility, even though this may not result in an efficient structure.

Keywords: Environment classification continuums; Environmental sub-systems; organisation structures; production systems.

INTRODUCTION

Prior to discussing the hypothetical construction project to which the evaluation model is to be applied, it is important that the term "production system" is set in its correct context. Much of the background to this discussion has existed within the general literature for many years and yet the construction industry largely appears to be unconvinced regarding the possible benefits of systems analysis. This paper intends to illustrate how systems analysis can be applied at a fairly basic level within the construction process activity of project management, and at the earliest levels of decision making.

The key aspect of the word "production" is that it denotes a planned action intended to result in a product of use; accidentally arriving at a product does not count. Planning is therefore a vital component of the production process. This is reinforced by consideration of the definition used for a system: *any group of entities which are inter-related so as to perform some function, or reach some goal, can be seen to be a system.* [Newcombe et al (1990)]. Moreover, systems have long been defined in terms of imports, conversion, and export (ICE) as proposed by Miller and Rice (1970: 3-13), within which the emphasis is on the planning of the conversion process. Key features of the conversion process are:

i) operating activities; work undertaken directly on the imports.

ii) maintenance activities; ensuring a continuous supply of imports (resources) from the environment external to the conversion process to replace those resources consumed by that process.

iii) regulatory activities; relating the activities within the conversion process to each other, their relevant maintenance activities and the environment.

Figure 1 illustrates the operation of a very simple (in terms of ICE) system for the production of clay bricks.

Moore, T A and Moore, D R (1997) Project management for the construction industry: an examination of a systems approach. *In:* 1997, P S-S (Ed.), *13th Annual ARCOM Conference*, 15-17 September 1997, King's College, Cambridge. Association of Researchers in Construction Management, Vol. 1, 295-303.

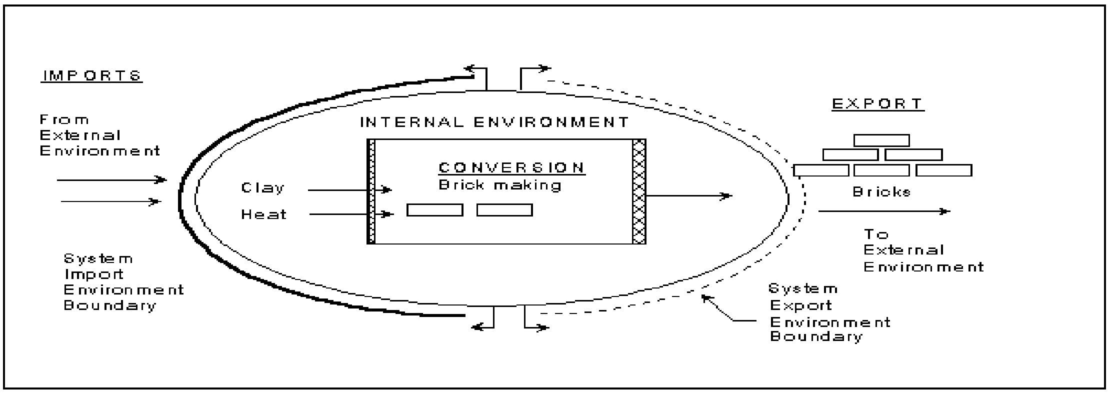

Figure 1. Outline Operation of a Simple Production System.
[Moore, Hague (1997)]

An important point with regard to the operation of production systems is that they can not control the environment which is external to them. This can be problematic in that the entity, or entities, which form the external environment may not be striving towards the achievement of the same goal as those entities forming the production system. The production system should ideally be capable of interacting with, and responding to, its external environment. There is evidence in the literature which indicates that systems can be set up so as to protect them, to varying extents, from the hostile actions of their external environment during the process of interacting with it [Shirazi et al (1996)]. When interaction is achieved with the external environment, the system is regarded as being "open", as opposed to "closed" when no interaction takes place. Most systems, particularly those involved in the production process, lie at a point somewhere intermediate to the open and closed conditions at either end of a continuum.

THE CONSTRUCTION PROJECT AS A PREDOMINANTLY OPEN SYSTEM

The organisation structure for a particular project should relate to the position of that project on the closed-open spectrum. For example, if a project tends toward the closed end of the spectrum, then the organisation structure for that project should be designed for efficiency and the entities forming the project system will be highly structured and rigid. Such structures were termed by Burns and Stalker (1961: 96-125) as mechanistic, being characterised by high levels of formalisation, centralisation and complexity. Construction projects can be argued to require organisation structures which tend towards the open end of the structure spectrum. This argument can be validated by the consideration of a construction project's characteristics in terms of Katz and Khan's (1978: 23-30) features of an open system. Figure 2 summarises the main points of such a consideration, and shows that a construction project requires a high level of openness in its organisation structure.

FEATURE	EXPLANATION	EXAMPLE
Importation of energy	Taking resources from the external environment	Buying materials.
Throughput	Conversion of imports, plus maintenance and regulatory activities.	Using a carpenter, timber and tools to produce a staircase
Output	Discharge of converted imports to external environment	Completed building not previously existing
Systems as cycles of events	Part of output fed back into system as a continuous loop	Proceeds from one house finances another house
Negative entropy	Acquiring more "energy" from imports than is needed, resulting in surplus capacity	Profit produced builds up reserves which stall the entropic process
Feedback	Environment information fed back to the system	Site accident log compared with others
The steady state	A dynamic equilibrium of imports and exports (outputs)	Work commences only when resources available
Differentiation	Functional specialism as a response to unknowns	Master mason develops into architect, planner etc.
Equifinality	Systems reach same end point despite different start conditions and paths	Production of a consistent artefact such as a power station
Integration	Co-ordination as a response to differentiation	Consider Latham!

Figure 2. Features of an Open System Considered in Construction Terms.

[Adapted from: Katz, Khan (1978)]

It is suggested that the common perception of the construction industry as being typically low profit with a high failure rate stems largely from the failure of the industry to provide relevant organisation structures for its projects. A particular example is that of the "throughput" feature, which requires a structure appropriate to the maintenance and regulatory activities encountered by a particular system's conversion process. Because the industry has been slow to adopt beneficial techniques such as systems analysis, it has largely failed to appreciate the need to attend not only to the conversion process, but also to the required maintenance and regulatory activities. Organisation structures which are sufficiently flexible to allow consideration of all production activities are therefore argued for.

ESTABLISHING RELEVANT ENVIRONMENTAL FORCES WITHIN A HYPOTHETICAL PROJECT

The initial requirement is to establish a project scenario for the hypothetical construction project. Key characteristics of the scenario are:

- developer is an established and reputable company.
- developer requires a state of the art office building.
- development site is in a prestigious area of a historic UK city noted for adverse climatic conditions.
- a rise in interest rates is seen as being probable.
- UK wages and prices are rising, but this trend is not being repeated in the rest of Europe.

- society has become increasingly litigious as a response to dissatisfaction and construction companies increasingly find themselves as defendants.
- management contracting has been selected as the procurement method.
- the selected management contractor is a young company with limited negentropy (negative entropy - see Figure 2).
- designs are not complete as work starts on site.

The above scenario must then be considered in terms of the environment, both external and internal, to the project. One technique for this consideration was proposed by Hughes (1989) in his examination of construction environments. The technique was to quantify information about a project's environment under two headings:

Mitigable - Unmitigable; the extent of a project team to control or moderate adverse environment effects. In order to quantify information of this nature the organisation structure / system being proposed for a project must be examined.

Definable - Undefinable; the extent of information available on the probable effect(s) of a particular environmental factor.

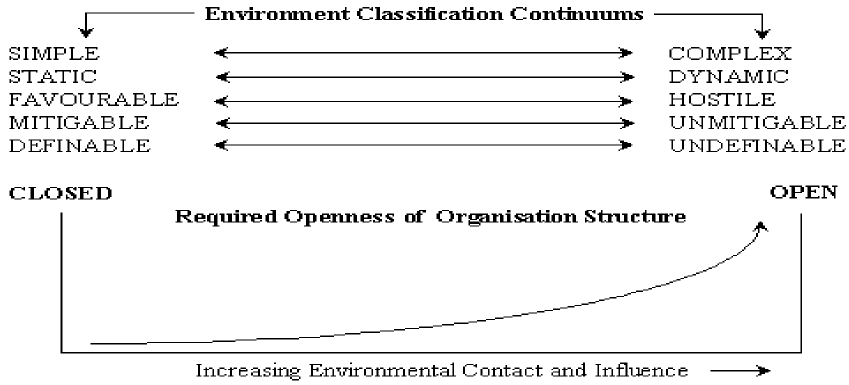

Figure 3. Simplified Representation of Relationship Between Project Environment and Organisation Structure.

This process of considering a project's environment can be added to by incorporating Mintzberg's (1979: 267-287) work on the favourable-hostile continuum, and also Duncan's (1971) work on both the static-dynamic and simple-complex continuums. An important point to consider here is that as information regarding the project is gathered under each of the above headings, the degree of openness required of the project's organisation structure will increase with increasing reliance on, and interaction with, the project's environment. A highly mechanistic system will require little interaction with its external environment and will continue to function so long as throughput is permitted and maintenance and regulatory activities are carried out. One basic example of such a system is an internal combustion engine, which interacts with the external environmental sub-systems only by requiring the continued availability of fuel. A simplified representation of this point is provided as figure 3.

However, in order to carry out this consideration of a project's environment in a robust manner, a structured approach is required. One such approach can be found in the previously mentioned work of Hughes (1989), which identified eleven environmental factors (referred to as environmental sub-systems) with a possible influence on construction projects. The eleven sub-systems are: cultural; economic; political;

social; physical; aesthetic; financial; legal; institutional; technological; policy, which Hughes considered in terms of his two continuums. Whilst this range of sub-systems may appear quite extensive, it is possible to extend the analysis further by accepting that environmental sub-systems operate not only at different levels (such as favourable - unfavourable) but also with different intensities. Differing levels of intensity have been identified by Osborn and Hunt [Woodward (1996: 82-83)] in relation to a project's immediate (micro) and wider (macro) environments. The authors therefore propose a number of revisions to the model developed by Hughes to calculate the environmental factor for a given project. The revisions are as follows:

- Whilst Hughes' original environmental sub-systems are retained, the criteria upon which they are assessed are revised to reflect the various continuum which can be used to determine an organisation structure's degree of openness.
- A weighting provision has been included in order that the relative potency of each of the environmental sub-systems within varying project circumstances can be reflected.

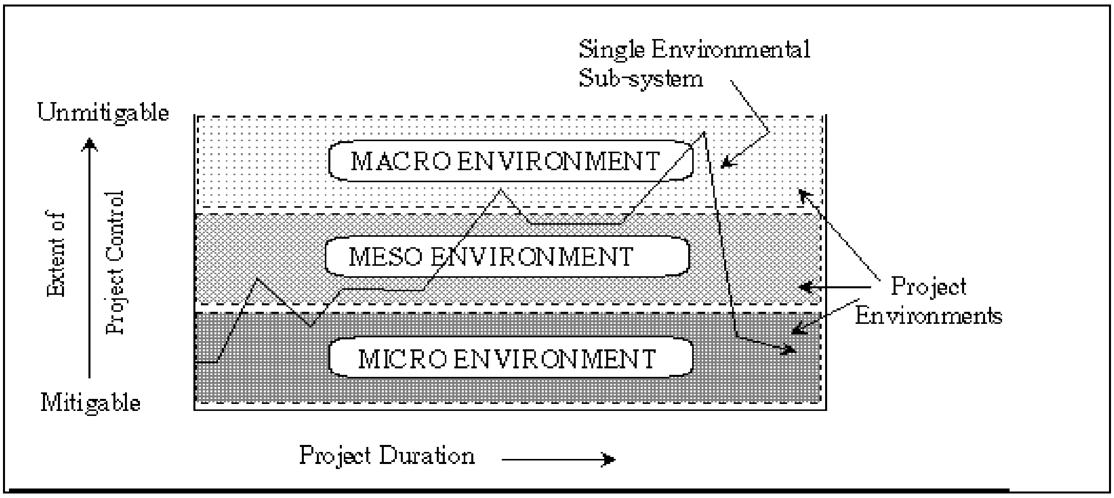

Figure 4. Suggested Project Environments and Varying Levels of Control Over a Single Environmental Sub-System.

- Assessment values are attributed to the five environmental classification continuums rather than to the environmental sub-systems.

The second of the above revisions results from the need to improve the realism of the model in terms of environmental sub-systems operating not only at different levels, but also with differing intensities (degree of influence) within varying project circumstances. Consideration of different levels of operation results from the work of Osborn and Hunt (1974) as developed by Walker and Kalinowski (1994), which considers the immediate (micro) and wider (macro) environments. The authors suggest that a third level, which may be referred to as the meso level, can be added in cases such as the hypothetical project where management contracting procurement methods result in the appointment of works contractors. Such contractors are argued not to be entirely controllable by the project, but are contained within it. This argument can be viewed as an extension of the suggestion that project organisation structures act as a buffer between the internal and external environments of the project. The nature of the suggested relationship between each of the levels and the continuums is illustrated in Figure 4.

A MODEL FOR ENVIRONMENTAL EVALUATION.

The proposed model takes each of Hughes' eleven environmental sub-systems and considers their effect(s) on the project from the viewpoint of the five closed-open continuums, with the effect being scored for each continuum as illustrated below:

- 0, sub-system tends towards the closed end of the continuum.
- 1, sub-system tends towards the centre of the continuum.
- 2, sub-system tends towards the open end of the continuum.

Following on from this, each sub-system is weighted in terms of its influence over the project:

- 0.5, sub-system exerts relatively little influence over the project.
- 1, sub-system exerts moderate influence over the project.
- 2, sub-system exerts considerable influence over the project.

Hence it is possible that a given sub-system may exist within the macro environment of a project, but still exert considerable influence on the project, as is the case with Building Regulations. Likewise, a sub-system may be complex but also highly defined, in which case the profile achieved across the five environmental continuums would be different to that achieved by a complex but highly undefined project.

By examining each of the sub-systems in turn, a score is computed for each of the continuum, with the five totals and their mean being plotted along the open-closed scale. The resultant position being the basis for determining the extent of openness required in the organisation structure for the project. Sample assessments for the hypothetical project outlined previously are given as Figure 5, and the total scores are presented as Figure 6.

Environmental Factor	Description	Weight	Simple-Complex	Static-Dynamic	Favourable-Hostile	Defined-Undefined	Mitigable-Unmitigable
Cultural	Social attitudes to an organisational system's behaviour	0.5 Score Weighted	 2 1	 0 0	 1 0.5	 1 0.5	 0 0
Economic	Concerns general economic activity	2 Score Weighted	 2 4	 0 0	 1 2	 1 2	 0 0
Political	Government policy and its effects.	1 Score Weighted	 1 1	 0 0	 1 1	 2 2	 2 2
Social	Concerns stakeholder views on the project	2 Score Weighted	 2 4	 0 0	 1 2	 2 4	 1 2
Physical	Topography, obstructions, hazards, weather, etc.	2 Score Weighted	 1 2	 2 4	 2 4	 1 2	 1 2
Aesthetic	Societal views on "good taste", includes fashion	1 Score Weighted	 1 1	 1 1	 0 0	 0 0	 0 0

Figure 5. Example Scores for Hypothetical Project's Closed-Open Assessment.**Environmental Continuum**	**Score (maximum total = 30)**
Simple - Complex	24
Static - Dynamic	14
Favourable - Hostile	19
Defined - Undefined	17.5
Mitigable - Unmitigable	17.5
MEAN SCORE	18.6

Figure 6. Environmental Continuums; Scores and Mean.

Analysis of the results indicates that the system representing the hypothetical project is neither closed nor open but can be classed as an homeostatic system (one capable of a certain level of internal adjustment in order to subjugate the effects of the external environment) whilst tending towards being open. The authors suggest that this result should be considered in terms of the work by Shirazi et al (1996) who found that when environmental conditions move towards becoming unfavourable for a given project, the parent organisation begins creating protective buffers around the project. This may particularly be the case when a project operates in a politically, or environmentally, sensitve environment. An example of such a situation would the complex project entered into by Shell which required abnormally deep wells to be set up in the mountainous regions of Columbia. The political sub-system to the project caused problems due to the actions of guerilla factions attacking what they saw as a multi-national company looting their country's natural resources.

CONCLUSION

The overall impression of the hypothetical project is that it is represented by a system which is more open than closed, and therefore requires an organisational structure which is designed with an emphasis on flexibility rather than efficiency. This is not to say that the consideration of efficiency can be ignored in the process of designing an appropriate organisation structure. By ignoring the need to balance efficiency and flexibility appropriate to a given set of circumstances, there would be no real need to adopt a contingency approach to project management. The model proposed by the authors has shown that it is sufficiently detailed to allow a realistic consideration of the key sub-systems within a project prior to the designing of an appropriate organisation structure.

A more detailed consideration of the results, along with the process of designing an appropriate organisation structure for the hypothetical project, will be presented by the authors in a subsequent paper.

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