FROM ACT TO OUTCOME -
A COGNITIVE MODEL OF CONSTRUCTION PROCUREMENT

Anita M. M. Liu, Department of Building and Construction, City Polytechnic of Hong Kong

KEYWORDS
Organisational behaviour, construction procurement, act-to-outcome process

Summary
Organisational behaviour can be modelled as an Act-to-Outcome process and this behavioural model is found to be applicable to construction procurement. The Act-to-Product and Product-to-Outcome paths are respectively the project realisation stage and post-occupancy stage in construction procurement. Organisational behaviour is governed by organisational goals, seemingly project goals affect the Act-to-Outcome process. There are a number of moderators to this goal-performance relationship, and these moderators (such as ability, task complexity, situational constraints) will in turn affect the Act-to-Product as well as Product-to-Outcome processes. In selecting an appropriate procurement system, the decision maker should take into account the effect of these moderators when choosing amongst the alternatives, and finally, an alternative selection method using conjoint analysis is illustrated.

Introduction
Ideally a construction project should live up to the expectations of all claimants involved. This implies that a well organised project team, in the form of a Temporary Management Organisation (TMO), has to ensure the success of the construction procurement process by achieving the stated project goals. Very rarely will there be a single goal. The multiple goals provided by various claimants will define the criteria of evaluating effectiveness of the TMO, and effectiveness as a result of the levels of goal attainment is captured in an Act-to-Outcome process.

While there are different groups of claimants to a project, such as the users, the client, and the project team, the perception of success (the Outcome) may be different to these respective groups. The human behavioural aspects in this project organisation are therefore not to be ignored, especially those underpinning the individual/group's behaviour in goal setting, and those affecting their goal commitment as well as perception of goal difficulty. These are all important attributes since the perceived level of an outcome is intimately linked with goal attainment

Act-to-Outcome
The Act-to-Outcome process is the product of Naylor's model of organisational behaviour, or rather, 'individual behaviour within organisations' as he aptly insists (Naylor et al 1980 p.1).

The project team constitutes an organisation, albeit a temporary one, and one suggested definition of project management and project organisation which sums up this 'temporary' nature is as follows (Adams and Barndt 1988):

The form of management known as project management was designed to "... provide sustained, intensified, and integrated management of the complex ventures" (Butler 1973) and to pull together a combination of human and nonhuman resources into "... a temporary organisation to achieve a specified purpose" (Cleland and King 1983). A project organisation is established for a limited period of time to accomplish a well defined and specified set of objectives -- to bring a new idea for a product through its conceptual and developmental phases to the point where the new product is available for use. When these carefully defined objectives are accomplished, the project is completed and the project organisation is terminated. Thus a project has a clear, finite, and well-defined life cycle, a fact which has long been used to differentiate "projects" from the more traditional, long-term "functional" organisation.
Since organisation is really the "planned coordination of two or more people who, functioning on a relatively continuous basis and through division of labour and a hierarchy of authority, seek to achieve a common goal or set of goals" (Robbins 1983 cited in Hendrick 1987 p. 349), and therefore organisational behaviour is really about the behaviour of individuals within the organisation to accomplish the goals set forth by this collection of individuals (ie. the organisation). As such, an Act-to-Outcome model should be applicable also to this project organisation and this model shall be examined of its feasibility to depict the construction procurement process, ie. the achievement of the organisational goal in terms of acquiring a building (the physical Product which constitutes an Outcome) through various Acts performed by the individuals in the organisation.

A cognitive theory of behaviour assumes that wo/man is rational (for the most part) and that as a systematic generator of behaviour, wo/man's actions are explained best in terms of conscious, thinking acts on the part of the individual (Naylor et al 1980). Those basic conscious actions of the individual are the actions of choice, or results of the process of choosing among alternatives (ie. judgement and decision making). One approach to understanding the Act-to-Outcome model is to examine the S-O-R (Stimulus-Organism-Response) sequence, a fundamental concept in the study of behaviourism.

Fig. 1 Stimulus-Organism-Response Cycle

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Organism</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVIRONMENT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>input</td>
<td>TRANSFORMATION (Project Management Process)</td>
<td>output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feedback</td>
</tr>
</tbody>
</table>

In Naylor's (Naylor et al 1980) model, behaviour is defined as an 'ongoing act' or process. The basic unit of behaviour in the Act-to-Outcome model is called the act, and is a result of the S-O-R sequence. An act has two defining characteristics or dimensions, the amplitude (total commitment to an act as defined by the amount or quantity of individual time and effort allocated by the individual to the task performing that act), and the direction (the specific kind of activity or process being carried out or performed). The Act-to-Outcome model is in fact as follows:

Fig. 2 Act-to-Outcome Model

<table>
<thead>
<tr>
<th>Act</th>
<th>Product</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Feedback</td>
</tr>
<tr>
<td>ACT</td>
<td>PRODUCT</td>
<td>OUTCOME</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feedback</td>
</tr>
<tr>
<td></td>
<td>PERCEIVED PRODUCT</td>
<td>EVALUATION</td>
</tr>
</tbody>
</table>
To complete this model, the role of cognition must be explained. Naylor and his associates argue that one needs to distinguish between perception as a process and perceptions which are cognitive states of awareness or knowledge. The perceptual process is the way in which specific perceptions, or cognitions are formed or created. Cognition plays a major role, and is a specific perception on the part of the individual. This may arise directly from the external world of the environment via primary sensory processes, thus, perceptions can be either of external states (environment) or internal states (self). Perceptions may be simple or basic cognitions, or may be complex. Cognition is therefore defined as "a perception (and therefore a conscious awareness) of a state of the environment or of one's self or of a relationship among states (contingencies)." (Naylor et al 1980 p. 16)

Outcomes have valences (whether positive or negative). Intrinsic outcomes are defined as those outcomes that occur (are created by and are perceived by the individual) as a function of the individual's own measurement system and evaluation system. Extrinsic outcomes are all other perceived outcomes received by the individual that are attributed to the environment. The valences of these perceived potential outcomes, when combined with perceptions of contingencies between products and received outcomes, result in utilities of the products, i.e. one's feeling - utilities - of the products, or one's affect (where affect is defined as a psychological state, or feeling, and therefore a cognition of pleasure, happiness, well being or satisfaction). One's level of aspiration is a crucial determinant in such evaluation of the outcome, since the level of aspiration is "the level of future performance in a familiar task which an individual knowing his level of past performance in that task, explicitly undertaking to reach" (Locke and Latham 1990 p. 110).

**The Construction Procurement Process**

Walker's (1989 p. 105) model of the construction procurement process depicts three stages, the project conception stage, project inception stage, and project realisation stage. In Walker's model, the 'client' refers to a sponsor of construction work who can generate the finance, information and authority necessary to embark upon the process. Construction projects start as a result of the influence of environmental stimuli upon prospective client organisations which create the motivation and need or opportunity to construct to reach objectives. Such stimuli may be economic, technological, sociological etc. and usually consist of combinations of different classes of forces. The basic response of an organisation to environmental stimuli is the result of its need to survive, above this level the organisation responds in order to expand as the result of its motivation. Survival is the basic goal which requires the organisation to maintain its position relative to those of its competitors for which it must continue to obtain a return acceptable to its environmental in terms of its role (eg. profit, service, acceptability). To integrate the two processes of Act-to-Outcome and Construction Procurement, the following model results:

**Fig. 3 The Construction Procurement Process**

**S-O-R**

- **Client's Objectives**
  - **Goal A**: a contribution to the client's objectives of real property
  - **Goal B**: the realisation of a new building
- **ACT**
- **PRODUCT**
  - **Perceived Product**: Evaluation
- **OUTCOME**
- **PROJECT INCEPTION**
- **PROJECT REALISATION**
- **POST-OCCUPANCY**

S-O-R: Stimulus-Organism-Response sequence
At the project inception stage environmental influences are transmitted to the potential client through his importation of information, energy and materials from the environment. The action of these influences will determine the initial decision. The project conception process will entail the consideration of each alternative within the environmental context and a decision will be made on the basis of the influence of the external factors. The assumed preferred decision of the project conception process (Goal A) requires the acquisition of real property. The project inception process will receive information, energy and material from the environment and will transform them in its task of identifying the appropriate intermediate decision (choosing among alternatives such as buying, leasing or constructing a new building). The assumed intermediate decision of the project inception process is the construction of a new building (Goal B). The process of arriving at the finished building is called the project realisation process and will again be determined by the environmental influences acting on the process.

Judgement and Perception

Judgement is part of the decision making process. (Decision making process consists of information acquisition, judgement and action). It is the stage in which stimulus objects are assigned locations on a measurement and/or evaluation continua. As pointed out previously, human beings are assumed to be rational under a cognitive model, and that their rationality involves the notion of attempting to maximise anticipated positive affect by deciding upon or choosing those options that they expect to result in the greatest positive, or least negative, affect. This assumption is formulated through the subjective expected utility theory (SEU) (Edwards 1961, Slovic & Lichtenstein 1971), assuming that individuals attempt to maximise anticipated satisfaction (or pleasure) associated with a choice alternative, i.e. the prime type of reward is a perceived outcome having some degree of effect which is a subjective cognitive awareness of a state of happiness or pleasure that is associated with the perceived received outcome.

Perceptual process, arguably, consists of both information acquisition and judgement. One 'screens' out which information to acquire, i.e., picks the stimulus s/he wants to judge and respond to. Therefore, basic perceptions (cognitions) about the environment are the result of an internal measurement system within the individual. This internal measurement system responds to the stimuli and the process of measurement is judgmental whereby the individual assesses the incoming stimulus characteristics and uses them to locate the stimulus on a descriptive continuum.

In fig. 3, the evaluation of the product (the physical entity of the completed building) is then carried out by different claimants to the project, e.g. the client, the users, and the project team members. In doing so, they assess the goal-performance discrepancy, i.e. the level of goal attainment to see if the performance has matched those set by the goals. When claimants have different goals, this leads to different assessment criteria. For example, post-occupancy evaluation aimed at users will produce quite a different set of assessment criteria (Preiser 1988, 1989; Liu and Lee 1992, Liu and Mo 1994). Furthermore, they may have a different set of measurement standards and therefore will perceive and evaluate the product differently, thus leading to different outcome valences or affective states.

As a cognitive model, the acts (responses to the stimuli) are goal-directed behaviours. This is also seen from Fig. 3, for example, goal A sets the target for carrying out an 'act' (goal A-directed action), and goal B further guides the 'act' on a desired path in the act-to-product process. The strength of this relationship between goals and action are moderated by five factors (Locke and Latham 1990 p.257), ability, commitment, feedback, task complexity and situational constraints. They moderate the goal-to-performance relationship in the following manner:

- Ability limits the individual's capacity to respond to a challenge. Performance levels off after the limit of ability has been reached (Locke & Latham 1990 p.257).
- Challenging goals lead to high performance only if the individual is committed to them. The effect of variation in goal commitment on performance is shown in Erez and Zidon's (1984) experiment which found that as commitment declined in response to increasing goal difficulty, performance declined rather than increased. Commitment is affected by 'authority' (power of authority to produce commitment, i.e. goals assigned by authority figures), 'peer influence', 'use of rewards or incentives', and 'individual's expectancy of being able to reach the goal or perform at a high level'.
Maximum performance following feedback is attained when individuals anticipate low satisfaction for performance at the same level again, have high self efficacy, and set high goals for future performance (Bandura 1988).

Research confirmed a significant moderating role for task complexity (Wood, Mento and Locke 1987). An explanation for this finding is that on simple tasks, the effort induced by the goals leads relatively directly to task performance. In more complex tasks, however, effort does not necessarily pay off so directly. One must decide where and how to allocate effort, eg. setting a goal for high grades may not actually lead to higher grades unless the student uses proper study habits and an appropriate course strategy based on knowledge of what the professor is looking for. This is more so for the project manager and team members in a complex task such as completing a construction project. Thus in more complex tasks, the plans, tactics, and strategies used by the individual play a larger role in task performance than they do in simpler tasks where the number of different strategies are limited and are generally known to all performers.

In summary, a specific, challenging goal has maximum effect when the individual has high self efficacy and ability, there is commitment to the goal, there is feedback showing progress in relation to the goal, the task is simple, and there are no blocks to performance.

Selection of Construction Procurement Systems

Researchers have been working on application of decision making techniques in the selection of construction procurement systems. They invariably suggest incorporation of utility approach and risk assessment/allocation in their models. For example, Gordon (1994) suggests to "Use Risk Allocation and Project, Owner and Market Drivers to Choose Contract Type" and "Use Judgement and Experience to Create the Final Contracting Method from Remaining Options" in his model, and Skitmore and Marsden (1988) suggest the use of "Multi-attribute Approach" where 'observers' are asked to subjectively assess the performance of each procurement path in relation to each criterion in turn and enter scores on a given scale.

Risk assessment and utility functions are suggested to be used, but a proper integration is required. Gordon's (1994) model has mentioned risk allocation/judgement but has not shown precisely how this might be achieved. It clearly points to the subjects' subjective risk judgement in each case. Skitmore and Marsden's model (1988) deals with utility and discriminant analysis and provides a basis for further development to incorporate the effect of the relationship between value and utility functions as a result of the subjects' risk judgement.

Locke and Latham (1990) have pointed out that there are five factors which affect the goal-action relationship. These factors are 'self-assessed'. i.e., the subject forms a judgement of his/her own ability, the task complexity, situational constraints, feedback and his/her commitment. These judgements will affect the value function of each procurement system in the sense that "risk is taken into account by a transformation on value, not directly by a utility function over objective attribute scales" (Barron et al 1986). If ability affects chances of successfully completing the project, then as self-judged ability decreases, the subjective probability of achieving success (attaining utility value u) being assigned to the project decreases. Hence, the subjects may assess all five factors which affect the goal-action relationship and subjectively judge the probability of success before choosing a

These moderators will affect the goal-performance relationship by way of the goal-action process, Act-Product process and Product-Outcome process as shown in fig. 4. They will affect the choice of acts to achieve the goals, then the performance of the acts in realising the products, and finally the evaluation of the outcome (by affecting the level of aspiration).

An alternative method for selecting procurement system is to apply conjoint analysis which models the decision maker's (DM) judgement profile (Srinivasan and Shocker 1973, Green and Srinivasan 1978, Samson 1988).
STEP ONE:
DM is asked to rank nine alternative outcomes (of the particular project which the DM is trying to find a procurement system). Each outcome is described by the probabilities of achieving goal attainment in each attribute. Here four attributes and three probability levels are used. The nine outcomes are generated by an orthogonal array (Green 1974) using the Conjoint Designer software (Conjoint Designer 1992). The ranks in the following example are generated by the author as an illustration.

<table>
<thead>
<tr>
<th>Probability Level</th>
<th>Attribute 1</th>
<th>Attribute 2</th>
<th>Attribute 3</th>
<th>Attribute 4</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>high</td>
<td>low</td>
<td>medium</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>medium</td>
<td>medium</td>
<td>high</td>
<td>medium</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>low</td>
<td>medium</td>
<td>medium</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>low</td>
<td>medium</td>
<td>medium</td>
<td>low</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>medium</td>
<td>high</td>
<td>high</td>
<td>low</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>high</td>
<td>high</td>
<td>low</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>low</td>
<td>low</td>
<td>high</td>
<td>high</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>medium</td>
<td>high</td>
<td>medium</td>
<td>high</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>medium</td>
<td>low</td>
<td>high</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

STEP TWO:
Part-worths are calculated using the Conjoint Analyser software (Conjoint Analyser 1992). Let $y_{jp}$ denote the level of the pth attribute for the jth stimulus (alternative). Let $S_j$ be the preference for the jth stimulus. It assumes the modelling function of:

$$S_j = \sum_{p=1}^{m} f_p(y_{jp})$$

where $f_p$ is the function denoting the part worth of different levels of $y_{jp}$ for the pth attribute. OLS (ordinary least square) method (Conjoint Analyser 1992) can be used to estimate all the part worth values for each attribute level (the following is an example being generated by the author based on the preference rankings shown under Step One).

<table>
<thead>
<tr>
<th>Probability Level</th>
<th>Part-worths</th>
<th>Speed</th>
<th>Quality</th>
<th>Cost Certainty</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>-1.000</td>
<td>-1.000</td>
<td>-3.000</td>
<td>0.333</td>
<td></td>
</tr>
<tr>
<td>medium</td>
<td>0.667</td>
<td>-0.333</td>
<td>1.000</td>
<td>0.667</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>0.333</td>
<td>1.333</td>
<td>2.000</td>
<td>-1.000</td>
<td></td>
</tr>
</tbody>
</table>
STEP THREE:
DM is now asked to consider among alternative procurement systems A and B. In doing so, s/he is asked to assign his/her assessed subjective probabilities of success $P_s$ (taking into account of moderators' effect) to the attributes.

<table>
<thead>
<tr>
<th>Procurement System</th>
<th>Attribute</th>
<th>Speed $P_s$ Part worths</th>
<th>Quality $P_s$ Part worths</th>
<th>Cost Certainty $P_s$ Part worths</th>
<th>Flexibility $P_s$ Part worths</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>med</td>
<td>0.667</td>
<td>high</td>
<td>1.333</td>
<td>low</td>
</tr>
<tr>
<td>B</td>
<td>high</td>
<td>0.333</td>
<td>med</td>
<td>-0.333</td>
<td>high</td>
</tr>
</tbody>
</table>

His/her choice of procurement system will depend on the larger sum of the part worths. It is therefore assumed that the DM in this case will decide to pick procurement system B.

Discussion

There are other ways of modelling risk judgement and therefore the following is hoped to arouse interest to develop other solutions. A decision is said to be riskless if the decision maker is certain of the multiattributed consequence associated with each alternatives under consideration (Barron et al 1984). In this riskless case, the problem is to select the most preferred alternative or to compare the relative values of alternatives. A decision is said to be risky if the decision maker is uncertain as to the consequence associated with each alternative but is able to express this uncertainty as a probability distribution over the possible consequences of each alternative. In this risky case a prescriptive solution to the problem is to select the alternative having the highest expected value (hence the 'expected value' has to be calculated).

Multiattribute utility theory consists of a class of models and scaling procedures for the measurement of preferences (von Neumann and Morgenstern 1947, Savage 1954, Edwards 1961). In a two-outcome situation (either winning or losing), an additive utility function is said to model an individual's subjective risk judgement well (Barron et al 1984). There are other risk models which attempt to describe how perceived risks depend on functional forms of probabilities and outcomes, eg. bilinear model (which consists of sign-dependent utilities and sign-dependent subjective probabilities, since it postulates that changes in good (winning) and bad (losing) outcomes are not equal in their effects on risk judgements, ie. similar to SEU, subjective expected utility, Edwards 1961), and conjoint expected risk model (which assumes risk judgement to be a weighted combination of the probabilities of winning, losing and receiving nothing) (Luce and Weber 1986, Mellers and Chang 1994). Coombs and Lehner (1984) propose a bilinear model as follows:

$$ R_i = -s_w(p_i) \cdot u_w(w_i) + -s_l(p_i) \cdot u_l(l_i) \quad \text{where} $$

$R_i$ is the risk judgement of gamble $i$; $s_w(p_i)$ and $s_l(p_i)$ are subjective probabilities of wins and losses, respectively; $u_w(w_i)$ and $u_l(l_i)$ are utilities of wins and losses, respectively. This risk model may be easily applied to the selection of alternative procurement systems. The win-situation is assumed to be a "good outcome" (terminology in line with risk judgement literature as in Barron et al 1984), ie. attainment of project goals through delivery of the 'product' as a result of the 'act' performed, and the lose-situation is assumed to be a bad outcome, ie., non-attainment of project goals. The $s_w(p_i)$ and $s_l(p_i)$ will differ according to the judgement of the individual subject to the moderators' effect, and $u_w(w_i)$ as well as $u_l(l_i)$ will have to be elicited from the decision maker or the experts.

Luce and Weber (1986) argue that "literature gives growing support to the assumption that people treat positive and negative outcomes differently" while Mellers and Chang (1994), although agree that subjects may adopt an additive model in fairly simple situations, point out that a variety of contextual factors may guide subjects to use one decision strategy over another, therefore no single decision strategy describes risk judgements over all situations.
Conclusion

The suggested method (conjoint analysis) obviously requires further development since there are unanswered questions like the assignment of probabilities to the systems, eg. currently these are assumed to be subjective probabilities, but it may be better to investigate properly the moderators' effect and obtain probabilities from past projects. There are five moderators, but the strength of their effects should be different, eg. perhaps ability (project team's past experience and knowledge affect ability) and situational constraints might be more important. If pairwise comparison of the various moderators' effects is desirable (rather than a holistic evaluation of the alternatives as provided by conjoint analysis), then the AHP (analytic hierarchy process) method may be adopted. AHP allows the fuzzy approach of turning linguistic variables into ratio weights (Saaty 1974, Saaty 1980, AbouRizk et al 1994).

A number of alternative subjective risk judgement models have been discussed, and these may be properly integrated into the procurement selection process; especially the bilinear model which postulates that the individual has different utilities attached to winning and losing (ie. the strength of the stimulus is also important).

References


