VALUE FOR MONEY AND FACILITIES PERFORMANCE: A SYSTEMS APPROACH

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One of the central arguments for procuring capital projects through PFI/PPP is that it provides better value for money (VFM) for the client organisation. The arguments in support of this claim rests largely on assumptions about the difference between the public and private sector methods of delivering services and the willingness and ability to manage risk. Thus VFM has become unavoidably associated with procurement through private contracting, in spite of being introduced prior to the introduction PFI/PPP in the UK. It is argued in this paper, that the development of a robust framework for VFM can best be achieved through systems understanding of a complex set of requirements. This paper develops a conceptual framework, revolving around the so called three Es (*Economy, Efficiency* and *Effectiveness)* that forms the basis for further research aimed at developing a model for the rigorous application of VFM tests for built facilities

Keywords: Value for money, systems analysis, cost effectiveness, cost benefit analysis

INTRODUCTION

Value for money (VFM) and PFI projects have almost become synonymous. Most references regarding the benefits from PFI in contrast with public sector provision are implicit rather than explicit. The Office of government commerce (OGC), (formerly the Treasury Task Force), for example, cites the main six key drivers of value for money in PFI projects. These are:

1. risk transfer,
2. the long term nature of contracts (including whole life costing),
3. the use of an output-based specification,
4. competition,
5. performance measurement and incentives,
6. private sector management skills.

It is difficult to see how drivers 1,4 and 6 can imply any other procurement route than PFI, as a pre-condition for VFM. The International Project Finance Association (IPFA)[1] is less coy on this issue and boldly proclaims that:

[1] IPFA is an international, independent, non-profit making organisation dedicated to promoting and representing the interests of governments and private sector companies involved in PFI, PPP and project finance for major infrastructure projects

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PFI projects deliver greater value for money and increased efficiency when compared with similar projects

The merits of this claim, however, are not the concern of this paper. The aim of this paper is to examine the extent to which the three Es (*Economy, Efficiency* and *Effectiveness)* can be consistently applied in the development of a VFM framework and related performance criteria for constructed facilities. In so doing, the paper examines how the drivers of VFM in PFI projects fit within the VFM framework.

DEFINITIONS OF VFM AND THE THREE ES

No explicit definition of VFM has been given. Rather it has been a term used to assess whether or not an organisation has obtained the maximum benefit from the goods and services it both acquires and provides, within the resources available to it. The achievement of VFM, however, is often described in terms of the three Es*,* which have formed a central plank for applying VFM tests to any expenditure proposal in the public sector (Butt & Palmer 1985**).** It follows, therefore, that an operational definition of VFM must derive from a definition of the three Es and how they relate to each other. The three Es are defined as follows:

- *economy* is defined as "minimising the cost of the inputs for a given activity having regard to the appropriate quality.
- *efficiency* refers to the ratio of inputs to outputs (doing things the right way).
- *effectiveness* is the degree to which an objective is achieved. (doing the right thing)

These definitions serve as a useful starting point and can be readily applied to very simple systems. However when systems become more complex, as they inevitably do, the implications of the three components need to be developed and tested for consistency and verifiability. This may be done through systems analysis.

In order to examine the extent to which the three Es can be consistently applied to different input/output combinations, a set of definitions and decision procedures have been developed, starting with elementary systems and progressing towards more complex ones.

Given that:

E_1 represents *economy*

E_2 represents *efficiency*

E_3 represents *effectiveness*

$\uparrow$ represents a gain or an increase

$\downarrow$ represents a loss or decrease

O represents neither gain or increase

$\rightarrow$ represents causal (if then) relationship between two variables, that is

$(a \rightarrow b)$ would read *if a then b*

/ represents 'on condition that', that is, a/b would read a *on condition that* b

$*$ represents a conjunction of variables that is $(a * b)$ would read *both* a *and* b

For simple systems, a gain in VFM can result from a variety of arrangements in *economy* and *efficiency*. A net gain occurs when ($\uparrow > \downarrow$). The net gain must be based on equivalent units. That is, if by using a more expensive input ($E_1\downarrow$), a saving in time is achieved, the saving in time must be translated into cost savings ($E_2\uparrow$) for the net gain to be determined.

It follows that a gain in efficiency (E_2) requires less input for the same output.

Then for a given output:

1. $(E_1\uparrow * E_2O) \rightarrow VFM \uparrow$
2. $(E_1O * (E_2\uparrow) \rightarrow VFM \uparrow$
3. $(E_1\uparrow * E_2 \uparrow) \rightarrow VFM \uparrow$
4. $(E_1O * E_2 O) \rightarrow VFM\ O$
5. $(E_1\uparrow * E_2 \uparrow) \rightarrow VFM \uparrow$
6. $(E_1\uparrow * E_2 \downarrow)/(\uparrow > \downarrow)\rightarrow VFM \uparrow$
7. $(E_1\downarrow * E_2 \uparrow)/(\uparrow > \downarrow)\rightarrow VFM \uparrow$
8. $(E_1\uparrow * E_2 \downarrow)/(\downarrow > \uparrow)\rightarrow VFM \downarrow$
9. $(E_1\downarrow * E_2 \uparrow)/(\downarrow > \uparrow)\rightarrow VFM \downarrow$

A gain in efficiency can be achieved by:

1. the same output for less input
2. more output for the same or less input
3. the ratio of output gain to input gain greater than one

Effectiveness cannot be analysed in the same way as *economy* and *efficiency* as it has to be judged against a standard, which is based on the requirement of the organisation. It is not just the output that is important but the effect of the output known as the outcome.

In practice, for complex systems, the conditions for the three Es are likely to interact in such a manner that the nature of the interaction will need to be considered in the analysis. For the purpose of the initial analysis however, it is helpful to follow a disaggregate model of the three Es and assume they operate independently as shown in Figure 1. Again, the output will be taken as fixed in order to examine the various arrangements by which inputs represented by *economy* and *efficiency* are transformed into outputs.

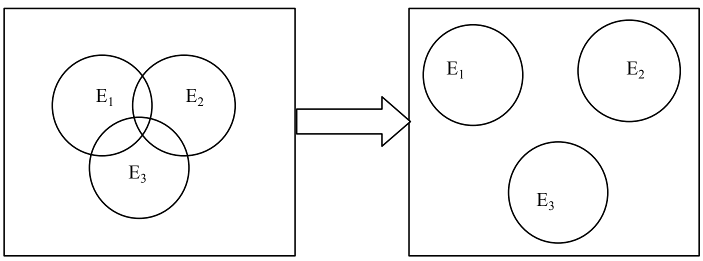


Figure 1 Diagrammatic models of relationships between the three Es

The determination of the three Es in a disaggregated mode can be established through the relationship between the inputs, processes and outputs as is shown in the following:

1. For any system *with one type of input* of quantity *I* at price *P* and one type of output of quantity *O*

It is necessary to distinguish between the minimum purchased input denoted by I_p and the minimum usage input denoted by I_u. The difference between I_p and I_u is part of a wider system, which includes design and input specification decisions. For example, waste from bulk ordering or due to uncoordinated design can distort VFM evaluations at the basic level of systems. It should, therefore be included in the evaluation at the higher level in order to establish an overall VFM evaluation

This implies that, at the most elementary level, the minimum usage input (I_u) represents the smallest amount that is necessary to achieve the required output and is denoted by *I.* It then means that:

Economy relates to the price *P* of the input *I*

Efficiency (E_f) is the ratio of output to input i.e.

Efficiency =O/I, also known as the yield, also known as the yield

Cost (C) = P I

It follows that for a given price of input *P*, maximum VFM is achieved when the output is produced at the lowest quantity of input. Thus producing the lowest cost input. Also if both P and O are assumed fixed, with a decrease in input I, a gain in VFM is achieved. That is when P is fixed, then within a required level of output *O*,

$$VFM \propto \frac{1}{I} \text{...and...} VFM \propto O$$

As the system becomes more complex, a trade-off exists between *economy* and *efficiency*:

2. For any system, *where there are alternative inputs* based on quantity I_x and I_y and price P_x and P_y for the same output of quantity *O,*

Figure 2: System with alternative inputs and one output,

For input I_x and input I_y

$$Yield_x = \frac{O}{I_x} \text{....and...} Yield_y = \frac{O}{I_y}$$

$$\frac{Yield_x}{Yield_y} > \frac{P_x}{P_y}$$

Where:

Then the use of input (I_x) would provide the greater VFM. As a generalisation, inputs with a higher yields ratio to prices ratio, provide better VFM

3. For systems *with two complementary inputs* I_1 and I_2 at prices P_1 and P_2 respectively (fixed ratio)

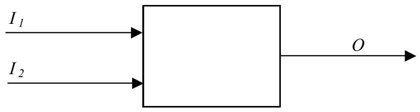


Figure 3: System with complementary inputs and one output

Efficiency of the combined inputs is:

$E_f = O/(I_1 + I_2)$ and the cost of inputs

$C = (I_1 P_1) + (I_2 P_2)$

For n inputs,

$C = (I_1 P_1) + (I_2 P_2) + + \ldots.(I_n P_n)$

That is, VFM is greatest when the following equation is minimum:

$$C = \sum_{i=1}^{n} (I_i P_i)$$

4. For systems with two competing inputs I_1 and I_2 at prices P_1 and P_2 respectively:

Figure 4: System with competing inputs and one output

A two-input, one-output system, where the inputs are substitutes, exhibit a pattern of production characterised by the changing returns to scale. For some production systems, given the same output, the rate of substitution of one input for another is found to change in a manner represented by an isoquant equation. The rate of change between the inputs is known as the marginal rate of technical substitution (MRTS).

From the isoquant equation:

$$K = \frac{x}{L^2} + y$$

This is derived from the Cobb-Douglas production function (James and Throsby 1973), where K = units of capital, L = units labour, x and y are values that determine the shape and position of the production isoquant.

James and Throsby (19973) have shown that if the relative cost of L and K is assumed to be fixed, given the price of labour is P_l and the price of capital is P_k, within a given range of output O, the total cost function is given by:

$$TC = LP_l + KP_k$$

The least cost combination of L and K, for the required output O is the one where the total cost line is tangential to the curved isoquant or where the derivatives of both equations are equal. That is, when:

$$-2l^{-3} = -\frac{p_l}{P_k}$$

Or more generally:

$$\frac{dK}{dL} = -\frac{P_k}{P_l}$$

From which, both L and K can be determined.

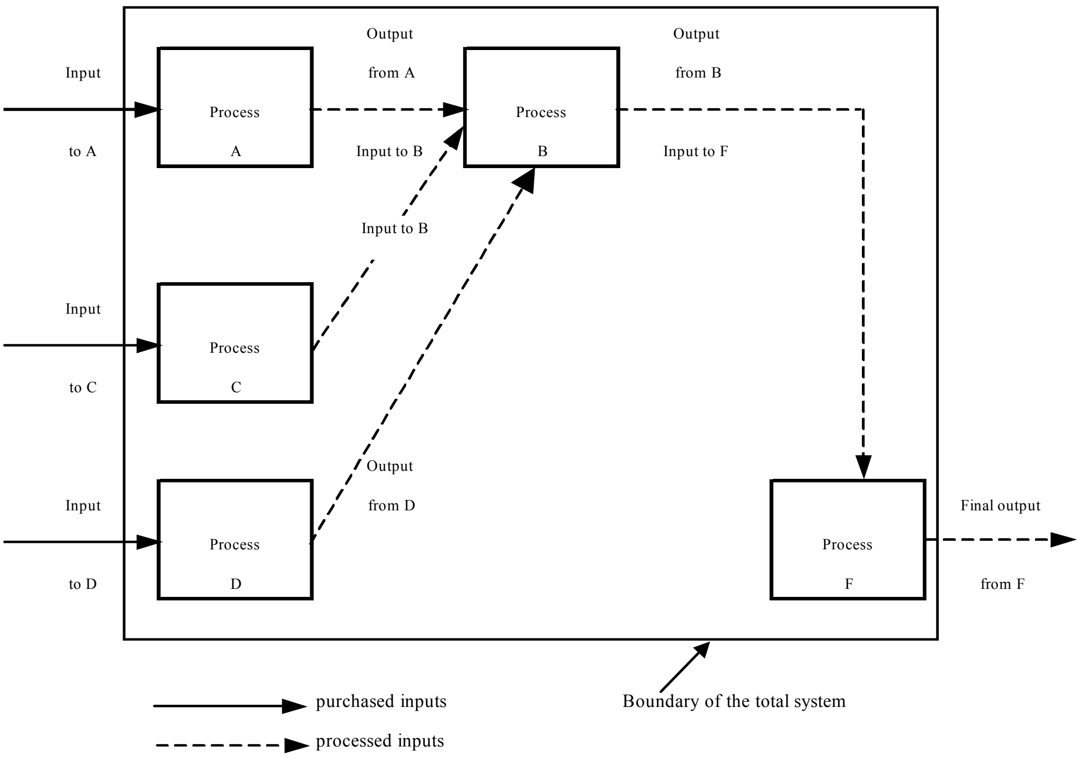
For this type of system there is a clear trade-off between *economy* and *efficiency*. The VFM test in this case is the combination of the two inputs, such that the derivatives of their isoquant and isocost functions are equal.

Thus far only inputs and their transformation process have been subjected to VFM tests. They are summarised in Table 1

Table 1: A summary of the arrangement of inputs for a simple system

INPUTS	TESTS FOR VFM
1. Single input with no alternatives	Lowest quantity of input for a given price
2. Single input with alternatives	Highest yields ratio to prices ratio
3. Complementary inputs	Least combination of quantity and price
4. Competing inputs (substitutes)	As above but based on the marginal rate of technical substitution of the inputs

Figure 5 A family of linked processes adapted from Hill (1983)



THE THREE ES AND SYSTEMS CONTROL

Because physical systems are subject to environmental disturbances, it is necessary to introduce systems control. Such control must address the appropriate level of system within a hierarchy of systems, or the stage in a sequence of processes. The control is achieved by introducing a feedback loop, which enables the actual output to be compared with the required or specified output, at suitable intervals of time. The feedback should reveal any variances in *efficiency* or *effectiveness* or a combination. The question of *economy* should be addressed within the procurement system.

As shown in Figure 5, one feature of systems complexity is the number of processes that are interrelated, which the output from one or more processes become the input of subsequent processes. From Figure 5, the *Effectiveness* of the total system relates to the final output of process *F*. It therefore sets the standards for the outputs of all the preceding processes. *Economy* relates to all purchased inputs and *efficiency* relates to both the total system and the individual processes of that system. That is, for each process, *efficiency* is the unit output per unit of combined inputs received for that process. For the total system *efficiency* is the unit of final output per unit of combined purchased inputs. Where the inputs are measured in the same units, *efficiency* is expressed as standard yields. Each process or groups of linked processes will have standard yields, which constitute the *efficiency* target

Efficiency of the total system however, is not the sum of the efficiencies of the component processes. Nevertheless, the inputs to the final process are dependent on the outputs of the preceding processes. Control must therefore be undertaken at both the micro level, where each of the linked process is under scrutiny and at the macro-level where the family of processes is examined as a total system.

DECISION ANALYSIS AND THE THREE ES

Decision analysis (DA) forms part of systems analysis (SA) and concentrates on comparing and ranking alternatives in the light of given objectives and constraints.

Within the discipline of DA two techniques can be used to select options on VFM criteria: Cost-effectiveness analysis (CEA) and Cost benefit analysis (CBA).

A. Cost effectiveness analysis (CEA) is used when the objective is specified and the purpose is to find the least expensive way of achieving it. More recently (American College of Physicians 2004) CEA has been extended to include a comparison of the relative values of strategies for achieving the desired outcome. Thus a new strategy is compared with current practice in terms not only of their costs but their effectiveness. The measure of cost effectiveness is given as:

$$CE.ratio = \frac{\cos t_{new.strategy} - \cos t_{current.practice}}{effect_{new.strategy} - effect_{current.practice}}$$

Put more simply, CE ratio = Δc/Δb, Where: Δc = incremental cost and Δb = incremental benefit. It follows that if the CE ratio < 1, the decision is cost effective. Thus CEA involves weighing the incremental cost against the incremental gain in effectiveness.

For this definition to be operational, however, the incremental gain must be measured on the same scale for both options under consideration. This raises a more general question as to how to measure an improvement from a change in strategy or procedure where the output is intangible. In the absence of any established indices, it is possible to establish a plausible set of values and weightings in order to derive an improvement index (*MI*). This can be done by group consensus or questionnaires and are analogous to the severity/importance index used by (Aniekwu 1995) and (Adams 1997)

The Group consensus method involves a group of size *N* who represents those who have an interest in the improvement. The group agrees on the attributes and their weightings. It then votes for each attribute on the basis of a perceived improvement.

$$MI = \frac{\sum_{j=1}^{n} S_j W_j}{\sum S}$$

The improvement index would be defined as - Where:

S_j is the rating given to the variable and W_j the weight assigned to that variable, $\sum S$ is the sum of the ratings. This is illustrated in Table 2

Table 2 **Example of improvement index (MI) based on consensus method**

	Attributes				
	x_1	x_2	x_3	x_4	
Weight (*W*)	1	3	2	4	
Votes (*S*)	6	8	3	2	
Improvement index (*MI*)	2.32			$\sum SW$	44
				$\sum S$	19

The advantage of the group consensus method is that it can be done reasonably quickly within the organisation with people who have a stake in the outcome of VFM decisions.

Comparing decisions on the basis of the CE ratio, however, is not sufficient to secure VFM. It is necessary to ensure that the preferred strategy meets the criteria of economy and efficiency. VFM requires all three Es to be examined simultaneously.

B. Cost benefit analysis (CBA) is used when decisions become more complex and where more than one beneficial outcome over a period of time has to be evaluated. Such decisions require a methodology that enables all the relevant benefits to be judged against their costs over time.

As such they follow the net present value (NPV) rule (*where PV is the present value of costs C and benefits B)* for any investment decision, which should be accepted for a single option if:

$$\sum PV_B > \sum PV_C$$

and for options *A*, *B* and *D, the condition for the preferred option A is only if:*

$$\frac{\sum PV_{B_A}}{\sum PV_{C_A}} > \frac{\sum PV_{B_B}}{\sum PV_{C_B}} > \frac{\sum PV_{B_D}}{\sum PV_{C_D}}$$

Both CEA and CBA generally take cost as a given. But cost is simply a proxy for the inputs to the process. In other words, when evaluating options on the basis of VFM, the definitions and decision rules, regarding the three Es still apply. In spite of selecting the option on CEA or CBA grounds, it may be possible to obtain the desired outcome for less expensive inputs.

The analysis of VFM in this paper can be summarised in the framework shown in Table 3, which will form a platform for the next stage of research in this area.

Table 3 VFM Framework providing a summary of processes and VFM components

Process	Value for Money Framework Conditions	VFM Component	Technique
Single process			
1. Single input	Highest yield	Efficiency	ratio analysis
2. Single input with alternative input	Highest yield to price ratio	Efficiency	ratio analysis
3. Complementary inputs	Least combination of quantity and price	Economy and Efficiency	Incremental analysis
4. Competing inputs (substitutes)	Least combination of quantity and price based on the marginal rate of substitution (MRTS)	Economy and Efficiency	Marginal anlysis
Linked process 5. Single input to each process	Highest overall yield	Efficiency of the overall process and effectiveness of individual processes	ratio analysis
Alternative process	Cost effective (CE) ratio < 1 1. Where output is fixed 2. Where an improvement is sought	Economy Efficiency and Effectiveness	Cost effectiveness analysis (CEA): 1. Incremental analysis 2. Multi-attribute analysis
Competing processes	Highest cost/benefit ratio	Economy Efficiency and Effectiveness	Cost benefit analysis (CBA) 1. Discounted cash flow 2. Multi-attribute analysis

CONCLUSION

This paper has sought to examine how VFM can be applied consistently with the aid of systems analysis. Consistently in this context is the application of concepts to a range of plausible situations at various levels of an organisation.

The existing guidelines for examining VFM deals under PFI are procedural rather then conceptual. Therefore, this paper sought to establish a clear conceptual framework of VFM by examining the various combinations by which the three Es give rise to changes in VFM. The three Es were examined using input/output analysis and aspects of decision analysis as part of systems methodology. A fundamental feature of systems methodology, which is important to this study, is the notion of hierarchy and complexity. As a consequence it is necessary to relate the level of system within an organisation, with the category of decision and the appropriate method of analysis.

Performance in relation to PFI projects are multi-layered, starting from strategic requirements of the facility to measurable outputs at the operational level. As decisions become more remote from the operational level, a method is required for handling multiple and conflicting requirements, known as outcomes. This was shown when seeking to establish an improvement index to measure cost effectiveness

The VFM framework provides a platform from which to examine more fully the role of Multi-Criteria Decision Analysis (MCDA) in the development of VFM criteria for

Facilities obtained through PFI and this will be the aim of the next stage of the research.

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