Whole-Life Cycle Costing (WLCC) Framework Proposal for PFI Road Projects

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Abstract: The introduction of PFI has forced the private/public sectors to consider the longer term implications of asset design. The PFI procurement philosophy requires greater integration of the design, operation and maintenance management processes to ensure that the long-term public sector requirements are satisfied.
PFI road projects require the successful consortia (SPV) to take full responsibility for designing, building, financing, operating, maintenance and replacement costs over the whole life of the concession period.

WLCC is concerned with optimising VFM in the ownership of physical assets by taking into consideration all the cost factors relating to the asset during its operational life. Optimising the trade-off between those cost factors will give the minimum WLCC of the asset.
WLCC seeks to optimise the cost of acquiring, owning and operating physical assets over their useful lives by attempting to identify and quantify all the significant costs involved in that life, using the Net Present Value (NPV) technique. The NPV method is also used in the analysis of whether a PFI project can achieve better VFM than a traditional procurement approach.

In DBFO roads, the Highway Agency in the UK compares the NPV of the projected payment under the DBFO contract over the period of the contract life (over 30 years) with the NPV of the costs of a traditionally procured Public Sector Comparator (PSC) over the same period. The calculation of costs of the PSC also takes into consideration the risks borne by the Highway Agency under the conventional procurement (HM Treasury Taskforce, 1999). This comparison is done for the selection of the Preferred Bidder in a PFI project.
The WLCC in this paper is undertaken as a holistic approach (that conceptualises the reality as an undivided whole) and considers VFM, Robustness, Affordability and Risk Transfer as

the main features. Each of these features and their relationships will be examined and a WLCC framework for PFI Road Project will be proposed.

Keywords: Affordability, NPV, Risk Transfer, Robustness, VFM, WLCC.

1. Introduction

Whole-Life Cycle Cost **(**WLCC) is concerned with optimising VFM in the ownership of physical assets by taking into consideration all the cost factors relating to the asset during its operational life. Optimising the trade-off between those cost factors will give the minimum WLCC of the asset.
The WLCC is a financial appraisal technique that normally uses Discounted Cash Flow (DCF) analysis to calculate future costs at today's prices and the results are presented in terms of Net Present Value (NPV).
According to Woodward (1997), it is important that management should realize the source and magnitude of life cycle costs so that effective action can subsequently be taken to control them. This approach to decision-making encourages a long-term outlook to the investment decision-making process rather than attempting to save money in the short-term by buying the assets simply with lower initial acquisition and capital costs.
A definition of life-cycle cost given by White and Ostwald (1976) is:

> *"The life-cycle cost of an item is the sum of all funds expended in support of the item from its conception and fabrication through its operation to the end of its useful life".*

WLCC seeks to optimise the cost of acquiring, owning and operating physical assets over their useful lives by attempting to identify and quantify all the significant costs involved in that life, using the Net Present Value (NPV) technique. WLCC which is synonymous with Life Cycle Cost (LCC) is concerned with quantifying different options so as to ensure the adoption of the optimum asset configuration (Woodward and Demirag, 1989).
According to Flanagan and Norman (1983) the objectives of LCC identified by the Royal Institution of Chartered Surveyors are:

- To enable investment options to be more effectively evaluated;
- To consider the impact of all costs rather than only initial costs;
- To assist in the effective management of completed buildings and projects;
- To facilitate choice between competing alternatives.

The LCC approach identifies all the future costs and benefits and reduces them to their present value by the use of discounting techniques through which the economic worth of a project or series of project options can be assessed.
The WLCC tries to convert all of the various life-cycle assessment (LCA) impacts to a monetary value and hence permit the calculation of a NPV of all effective costs. The main elements of WLLC are:

- Initial capital costs;
- Life of the asset;
- Discount rate;
- Operational and maintenance cost;
- Disposal cost.

In PFI projects, tenders are evaluated against various criteria in different assessment areas (Blackwell, 2000). General evaluation criteria may include:

- Innovation;
- Compatibility with operational approach;
- Deliverability;
- Flexibility;
- Risk transfer.

The NPV method is used in the examination of the relevant financial aspects of PFI projects. Tender evaluation is focused on the overall cost of services (i.e. the overall NPV of a tender's unitary charge) over the contract life or the whole life-cycle of a PFI project. The NPV of the residual value of the asset of a PFI project is also assessed if the asset reverts to the client at the end of the contract period. The NPV method is also used in the analysis of whether a PFI project can achieve better VFM than a traditional procurement approach.
In DBFO roads, the Highway Agency in the UK compares the NPV of the projected payment under the DBFO contract over the period of the contract life (over 30 years) with the NPV of the costs of a traditionally procured Public Sector Comparator (PSC) over the same period. The calculation of costs of the PSC also takes into consideration the risks borne by the Highway Agency under the conventional procurement (HM Treasury Taskforce, 1999).
The above comparison is done for the selection of the Preferred Bidder in a PFI project.
The relevant European Community procurement law requires transparency of the award criteria for the appointment of the preferred bidder (winner) and the award of the contract. The following are common criteria that a bidder should satisfy to be selected as the preferred bidder and subsequently awarded the contract (HM Treasury Taskforce, 1999):

- Meeting the Output Specification;
- Achieving Whole-life Value For Money;
- Acceptance of key contract terms and required transfer of risks;
- Confirmation of access to finance;
- Affordable unitary charge;
- Creation of a cohesive consortium.

2. Literature Review

Whole-life Cycle Costing (WLCC) is an investment appraisal tool which considers the value of a construction project over the selected assessment period. It facilitates the determination of the best value design solution; the provision of a functional and easily managed and flexible asset and long-term budgetary forecasts are calculated facilitating the generation of a sinking fund to cover whole-life cycle costing throughout the life of the facility (EFCA, 2003).
There are a number of definitions for whole life costing, but one currently adopted by the CRISP Performance Theme Group is:

> "the systematic consideration of all relevant costs and revenues associated with the acquisition and ownership of the asset" (CRISP, 1999).

Kelly et al, (2004 p.311) defines whole life costing as:

> "a technique for economic evaluation which accounts for all relevant costs during the investor's time horizon, adjusting for the time value of money and a methodology for predicting present and future costs for the purpose of comparing options and/or determining the most probable future facilities management cost of a facility".

For construction the WLCC= ∫ (capital or procurement costs + recurring or occupancy costs). The capital costs are: initial construction + interest + fees and the recurring costs are: rent + rates + cleaning + maintenance, repair, replacement/renewal + energy and utilities + dismantling and disposal + security and management over the life of the asset.
These final costs are shown at present day value for comparison purposes involving the use of discount rates. This establishes the amount which needs to be invested today in order to maintain the asset over its life.
There are emerging drivers for the take up of whole life cycle costing. Initiatives within the industry, such as Latham Report (1994) and the Egan Report (1998), have set the construction industry targets for cost savings which have to be set in the context of whole life cycle costing.
A whole life cycle costing approach encourages decision-making that takes account of durability, future running costs, and maintenance requirements. The WLCC therefore is a tool for encouraging the design of assets that are more compatible with the concept of sustainable construction.

An integrated approach to design, construction, operation and maintenance with input from constructors and their suppliers can improve sustainability, design quality, increase buildability, drive out waste, reduce maintenance requirements and reduce whole-life costs. The key issue is that the WLCC focus should start from the business case by increasing the value in the operational aspect while keeping the maintenance as low as possible. Time and effort spent in the design stage will save significant amounts of money later.

According to The Royal Academy of Engineering (1998) the relationship between Capital Cost: Cost in Use: Business Costs is 1: 5: 200 meaning that to operate and maintain an asset costs 5 times the capital costs over the life of the asset and the cost to the business, including salaries and staff productivity, occupying the asset is 200 times the capital cost.
WLCC is about understanding the balance between Capital Costs and Costs in Use (life-cycle costs) to deliver performance or service level required for an asset (WLCF, 2004).

Another important issue in relation to PFI road projects is the performance of the constructed asset. Performance means "quality of function/output along with constant process improvement" (Best & De Valence, 1999, p.200). The performance criteria, in order to avoid the misinterpretations of quality, are structured, objective and comprehensive in the Payment Schedules of the road projects. The Unitary Charges in the case study projects for the research undertaken has taken into consideration both the physical performance (such as maintenance, durability and environmental impact) and functional performance (driving comfort, safety and easy access).

The introduction of PFI has forced the private/public sectors to consider the longer term implications of asset design. The PFI procurement philosophy requires greater integration of the design, operation and maintenance management processes to ensure that the long-term public sector requirements are satisfied.

PFI road projects require the successful consortia (SPV) to take full responsibility for designing, building, financing, operating, maintenance and replacement costs over the whole life of the concession period.

The WLCC in the case study research is undertaken as a holistic approach (that conceptualises the reality as an undivided whole) and considers VFM, Robustness, Affordability and Risk Transfer as the main features.

3. Research and WLCC Framework

This paper is based upon two detailed case studies of major UK PFI Road Projects; A92 Upgrading between Dundee and Arbroath and Newport Southern Distributor Road (NSDR). The findings have been triangulated against a previously published PFI road project case study (Eaton & O'Connor, 2002a, b). The case study was selected as the most appropriate holistic mechanism for data collection (Akbiyikli, 2005).
This section critically examines and proposes the WLCC Framework required for achieving a successful PFI road project.

The WLCC Framework is a tool used to achieve the "Project Life-Cycle Costs" CSF for a PFI road project since it include all first costs (actual asset costs and all the costs associated with construction and completion of the asset) and future costs (all costs associated with operating and maintenance of the asset over its anticipated service life). It has a major impact on the financial model balance.
WLCC is one of the major areas of risk and uncertainty in the PFI process. Reliable data, according to the information from a SPV respondent in the road projects, does not exist but it is building up an experience data base for road projects. According to the same SPV respondent the Councils have taken WLCC as a feature in deciding the option appraisal in favour of PFI procurement in the road projects. The supporting argument to this was the financial model for the whole life cycle of the road projects. The Lenders also requested in their due diligence review a WLCC approach for the projects from the private sector.
The respondent from the SPV side expressed clearly the need for an agreed whole life framework within which the supply and demand sides must work. The private sector was not quite clear how the Council calculated its WLCC integrating it into the PSC in comparison with their Best and Final Offer (BAFO) for the whole life of the road projects.
When evaluating the WLCC four parameters emerged:

- VFM;
- Robustness;
- Risk Transfer;
- Affordability.

Each of these parameters and their relationships to WLCC are now examined.
There is a close relation between Value for Money (VFM) and WLCC. VFM is the optimum combination of WLCC and quality to meet the user's requirements (OGC, 2003). VFM is achieved by meeting the needs of the end-users with a higher quality project at lower whole-life costs. Awarding contracts on the basis of lowest price tendered for construction works is rarely VFM; long-term value over the life of the asset is a much more reliable indicator. It is the relationship between long-term costs and the benefit achieved by public sector that represents VFM (ibid). For the Public Sector Sponsor demonstrating VFM is a statutory legal

obligation. Hence achieving VFM is of vital importance in the successful delivery of a PFI road project.

A respondent from SPV said: *"We concentrated together with the Client on WLCC since our first meeting with them and continued till we became the Preferred Bidder. We did this consciously knowing the relationship with construction, operation and maintenance costs and the benefits that the Client would get at the end from the NSDR project. We and the Client were convinced of the whole value of the project"* (Respondent, 01.10.2004)
Another respondent from the SPV said: *"in the NSDR project the WLCC Model has been revised a couple of times in collaboration with the Lenders and the SPV's own financial and cost advisers in order to remodel all the associated costs with the anticipated road project life"* (Respondent, 01.10.2004).

There is proportionality between VFM and quality parameters. VFM is maximized, at least in part, by maximizing the quality parameters (level of services provided, performance of services, fitness for purpose. minimize environmental impact, extended useful life, etc.) (Best and De Valence,1999 p.17).

Value for Money (VFM) reveals the economic efficiency from the Public Sector Sponsor's side. VFM can be expressed as: VFM= Public Benefit (PB) / Public Cost (PC) and always has to be VFM>1.

The Public Sector Sponsor's aim is: "to procure a service that is acceptable Value for Money $(VFM)_{accept}$ subject to affordability".

Affordability is a measure of the ability to meet the Public Sector Sponsor's annual expenditure (the Unitary Charge Payment) that is paid to the SPV on a yearly basis. What the Public Sector Sponsor wants is a project from the Private Sector's side that is below its affordability. Affordability can be altered by the stakeholders and is expressed as:

Affordability =∫ (VFM, Robustness, Risk Transfer).

The Public Sector Sponsor seeks to make the SPV pursue its WLCC aim by using different mechanisms:
1. Risk transfer;
2. Output-based Specification;
3. Performance Payment;
4. Task integration;
5. Long-term contract;
6. Variable Concession Periods;
7. Competition and Innovation.

These mechanisms generate incentives and opportunities for the SPV to minimise its Whole Life Cycle Costing $(WLCC)_{SPV}$ which may translate into better VFM.

The WLCC and affordability are the governing parameters of VFM and the entire PFI Bid is based on the evaluation of the WLCC of the project. The aim of the Public Sector Sponsor is to lower it to a minimum.

The SPV in NSDR road project always used function-based solutions to achieve cost improvements without sacrificing the required performance. The value management done in both road projects focused on the elimination of redundant performance; that is, the avoidance of expenditure on any item of construction that does not add value to the project or which makes the output of the project achieve more than its required function as a road or as a bridge. Both case study projects, having the same construction contractor both in the SPV and in actual works execution, were good examples for the function-based value management approach.

A WLCC Framework for PFI Road Project is proposed in Fig.1 below.

The proposed framework contains the interrelationships between risk, value and function. Within this framework the supply (private) and demand (public) sides are working and interrelating; and efficiency, effectiveness, innovation and certainty in the framework is measured relative to the Public Sector's Output Specification.

The WLCC parameters are innovative and have different outputs for the private and public sectors. The SPV has payment as the output of the cycle which comprises an availability element and a shadow-toll element. The payment, reflecting the SPV's bankability and the payment mechanism are closely related to the performance of the constructed road since they incorporate the interrelations between risk, quality and function.

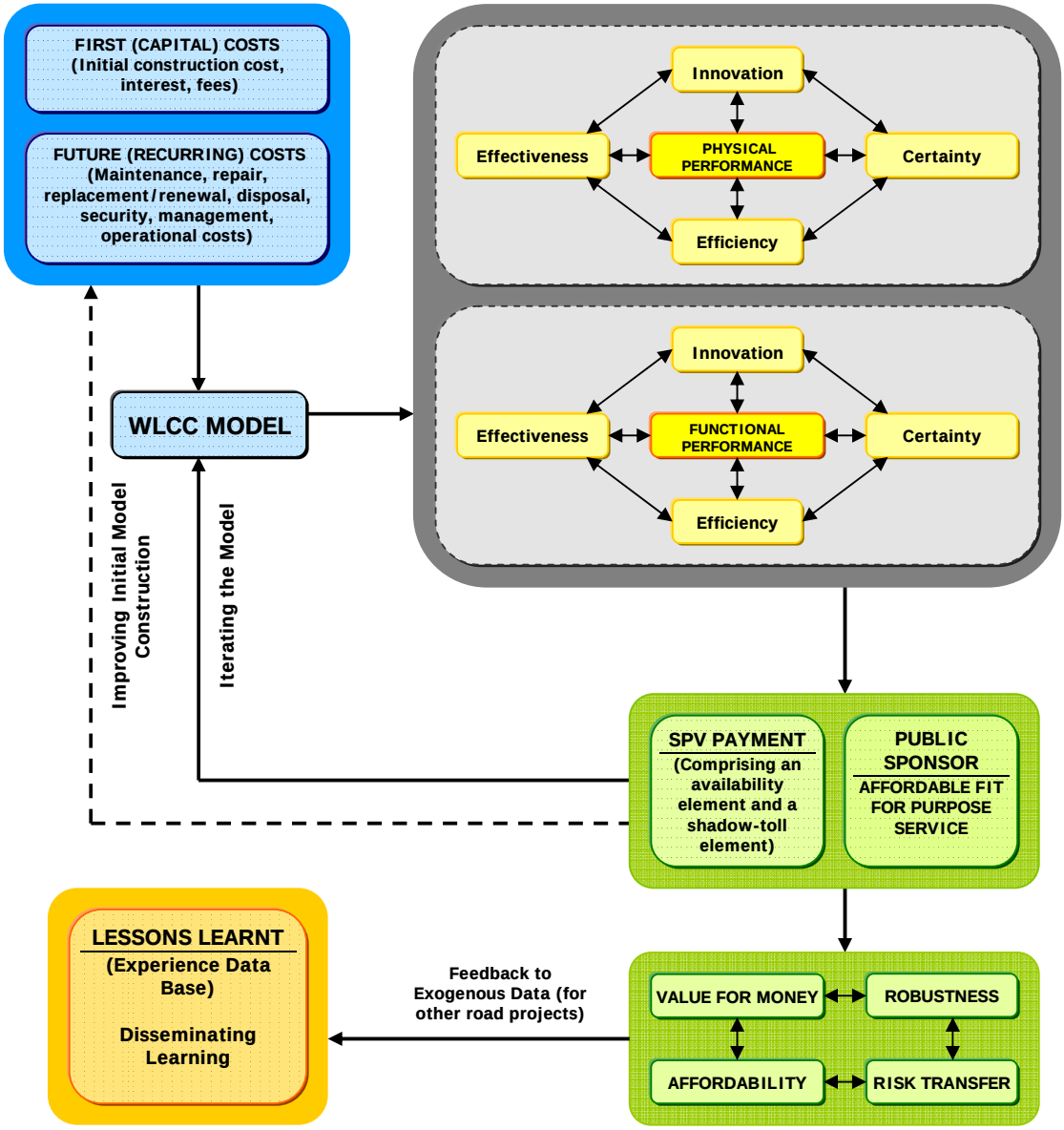

Fig. 1: WLCC Framework for PFI Road Projects (Akbiyikli, 2005)

The Public Sponsor has "Affordability" and "Value for Money" as the output of the cycle. Affordability for the Public Sponsor is the ability to access to funds and that the expenditure of the available funds provides an adequate return when compared with other investment alternatives.

The "Risk Transfer" refers to the balance achieved within the agreements between all of the parties in relation to accepting the financial consequences should a risk occur; and a risk should be allocated to the party best able to manage and control the risk.
The "Robustness" of the Project arrangements refers to the concurrence of the individual aims with the main project objectives. The project arrangements should be equitable between all parties, such that all parties should have the ability to complete a particular project without the necessity for 'step-in'. Thus no party conceives the agreement as 'unfair'. All parties should feel that they have not been disadvantaged by the arrangements. A satisfactory

Robustness arrangement would be one that all parties would be prepared to execute for subsequent projects.

The main philosophy behind the WLCC framework for PFI Roads in this study is:
An integrated approach to design, construction, operation and maintenance with input from constructors and their supply-chain to improve sustainability, design quality, increase buildability, drive out waste (lean construction) and reduce maintenance requirements.

A generic definition of WLCC for PFI road projects is proposed as follows:

"WLCC is a proactive, iterative, continuous and systematic approach which maximises the physical and functional value of a road project by managing its development from Business Case to Disposal according to the value requirement of the Public Sponsor". (Akbiyikli, 2005).

The facilitators of the WLCC process are the Public Sponsor and the SPV and its supply-chain.

Accurate WLCC increases the opportunity for efficiency and effectiveness improvements and can improve the availability of the PFI road during the concession period. It is therefore critical that sufficient attention is given to achieving accurate project whole life-cycle costs. Both the public and private sector can improve their strategic decision-making by improving the accuracy of their WLCC analysis in future PFI road projects.

4. Conclusions

The research case study analysis has identified among other issues the following:

- The PFI road projects required that capital expenditure and maintenance costs were considered throughout the bidding stages in order to arrive an effective Whole Life-Cycle Costing;
- In the PFI road projects the competitive and negotiation processes which benefits the Public Sector, required the Contractors to be innovative and cost conscious. The Private Sector benefited through long-term cash-flow and managing its supply chain with improved integrated solutions, and the introduction of cost efficiencies and WLCC analysis in design and sustainable solutions;
- The Financial Model which considered the Whole Life-Cycle Costing foresaw guaranteed expected service delivery and maintenance costs which are cardinal issues for affordability of the public sector. The Public Sector caps its final service costs at predetermined and agreed levels through the Project Agreement between Public and Private Sectors;
- The PFI gave the opportunity to the Public Sponsor to make the Special Purpose Vehicle (SPV) to minimize its WLCC which may translate into better service and better VFM;
- The WLCC and the PFI Contractual Framework ensured SPV ownership and thus a Zero Defect target at all levels of the supply chain. The WLCC, the necessity of the PFI's long-term service provision and the requirement of Zero Defect Target have resulted in an improved efficiency provision to the Public Sponsor and end user;
- The WLCC framework required the Contractors to be innovative and cost conscious; forced the SPV to introduce improved integrated solutions and project development

methodologies; and forced the Private Sector in general to think PFI's sustainability rationale, namely to minimize life cycle costs, to reduce source and waste, increase constructed asset efficiency and create safe road network.

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