REPACKAGING CONSTRUCTION MEGAPROJECTS AND REDEFINING TECHNOLOGY TRANSFER

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ABSTRACT

Studies in many developing countries have indicated that inappropriate work packaging has contributed considerably to problems that emerged on construction megaprojects. For example the geographical or functional demarcations of the works often leads to complaints as to either too large or complex packages to accommodate domestic contractors, or too insignificant packages to attract competent international contractors. Other complaints may relate to the inappropriate separation or otherwise of various design, construction and financing functions and sub-functions.

Parallel complaints have also lamented the lack of genuine ‘technology transfers’ between international and domestic contractors, despite initial intentions, promises and even contractual provisions.

This paper proposes a framework within which an appropriate procurement system with suitable work packaging may be selected for a particular project. It also espouses a paradigm of ‘technology exchange’ which is based on necessarily mutual transfers of different components of ‘technology’ between project participants or Joint Venture partners. This is based on a wider conceptualisation of ‘technology’: as including the four components of ‘Technoware’, ‘Humanware’, ‘Orgaware’ and ‘Inforware’ - as previously formulated in an ESCAP project. It is expected that synergistic two way technology transfers (or ‘exchanges’) will be more attractive and thus more likely within an appropriate procurement/ packaging framework.

Information technology (IT) must be harnessed in developing databanks of: (a) options along with a codification of their strengths and weaknesses in respect of procurement sub-systems/ packaging arrangements and (b) organisational strengths and weakness profiles in terms of potential technology exchanges with other possible project participants/ partners - so as to simulate and select from a series of suitably synergistic combinations. IT will also be needed to monitor the progress of each such proposed/ selected system - in terms of packaging, partnerships and management, so as to facilitate evaluations and feedback that will in turn help to formulate a 'selection model cum advisory system' and thereby further improve future selections.

BACKGROUND AND INTRODUCTION

Latham’s call for ‘constructing the team’ - in the context of perceived structural defects and attitudinal distortions in the U.K. construction industry (Latham, 1994) - is indicative of ongoing introspective reviews of industry deficiencies worldwide; and may thus be translated into pressing demands for ‘re-engineering’ construction processes and in fact ‘reconstructing the team’.

Cliched complaints about the unhealthy fragmentation of design and construction functions (and sub-functions/ specialties) have led to re-integration initiatives such as ‘design and build’/turnkey and even BOT type ventures that incorporate part of the financing function. However, the emerging alternatives have highlighted a new need - to adequately inform clients and even their advisors of the relative merits of different procurement options; and of criteria and methods to be used in assembling appropriate construction project procurement systems (Kumaraswamy, 1997a).

Many high profile megaprojects in developing countries have focused attention on inappropriate work package demarcations that have either excluded domestic participants or discouraged healthy international competition; while also often falling short on performance expectations. Other complaints relate to frequent failures to achieve the envisaged ‘technology transfers’ that were expected to enrich the local industry.

In a consolidated approach to such issues, this paper proposes the needs: (a) to re-conceptualise a more holistic ‘procurement framework’ for construction megaprojects, which highlights the various related choices to be made in assembling a system appropriate to a given project; and (b) to harness the potential of Information Technology - in presenting all the available options and their relative merits, to clients and their advisors; and also in assisting in the selection of suitable and compatible procurement sub-systems and project participant groups. A monitoring and evaluation sub-system would in turn harness feedback from ongoing and completed projects to update the databanks and thereby enhance the quality of future procurement decisions. Such decisions would, for example, relate to work packaging, selection of contract types and of compatible Joint Venture partners, that would in turn facilitate technology transfer/ exchange and boost the longer term development of the domestic construction industry.

THE CRITICALITY OF WORK PACKAGING IN MEGAPROJECT PROCUREMENT

Short-term Risk Apportionment and Long-term Industry Development

Previous comparisons of the relative advantages of different ‘types of contract’ for a given project scenario, have often neglected the crucial front-end decisions on the demarcation of work packages - for example in terms of (a) location (eg geographically separated work areas in roadworks projects), (b) operations (eg: separation of earthworks, foundations/ sub-structures etc); or resource provisions (eg: materials, labour, equipment, finance and management; as in ‘labour-only’ contracts). Figure 1 has been formulated to highlight and develop in more detail the foregoing options in work packaging in particular - in relation to a previously proposed holistic general procurement system model (Kumaraswamy, 1997b).

It is noted that the choice of ‘functional grouping’ (relating to design/ construction/ management packages) is connected to both the ‘work packaging’ and the ‘contractual’ sub-systems. Such ‘overlaps’ are useful in ensuring compatibility of the various sub-systems that need to be assembled into an appropriate procurement system.

Although procurement systems have often been selected almost by ‘default’ - for example to resemble those with which the main stake-holders are familiar - innovative approaches to considering alternative systems are supported by arguments to design a system to reflect the desired risk allocation objectives of the project clients (Kumaraswamy, 1997c). While the foregoing would accommodate the shorter term project objectives, a parallel argument is added in this paper, - to also incorporate the longer term/ broader objectives of domestic industry development in the case of megaprojects in developing countries The latter would then be expected to facilitate the faster development of domestic client, consultancy and contracting organisations through Joint Ventures and tangible technology transfers/ ‘exchanges’.

Megaprojects in Developing countries

That appropriate procurement protocols can also accelerate industry development has been demonstrated and/or advocated, for example by: (a) Ofori and Teo (1996) - who described such contributions of appropriate procurement policies in Singapore; (b) Abdul Aziz and Ofori (1996) - who documented the considerable impact of Government procurement policies on the development of domestic contractors in Malaysia; (c) Gounden (1996) - who explained how participant capacities and competitiveness were to be increased by the ongoing 'Procurement Reform Initiative' in South Africa; and (d) Kumaraswamy (1994) - who attributed many disruptions and distortions in the Sri Lankan construction industry to inappropriate procurement policies.

A useful case study emerged from a 1992 World Bank sponsored investigation into the roadworks sub-sector in Sri Lanka. A generic problem was also recognised in many foreign funded megaprojects in developing countries - in for example, the apparent 'Catch 22' paradox of: (a) not providing domestic (local) contractors with work opportunities because they have inadequate experience/ capacities, while (b) these contractors can hardly be expected to develop their experience/ capacities, unless they are provided opportunities for such work. Sri Lanka thus suffered inflated project costs arising from the mobilization of foreign contractors, even for items of work that could have been easily handled locally.

The Joint Ventures that were eventually formed in a few cases, were often merely for the purposes of prequalification for certain work, to satisfy the government and some multilateral agencies which had begun to incorporate incentives for Joint Ventures; for example as in the 7.5% tender price preference margins for domestic contractors (or certain types of Joint Venture with them) in developing economies available on some World Bank (World Bank, 1992) or Asian Development Bank funded projects.

The 'action plan' formulated by the study team following the aforesaid World Bank sponsored investigation, incorporated many proposals that focused on improved procurement systems (Kumaraswamy, 1994), for example:
(a) increasing opportunities for 'Local Competitive Bidding' (where most projects had been previously restricted to 'International Competitive Bidding' or 'Limited International Bidding') by reducing package sizes.
'Slicing' of work packages, both vertically (dividing the length of road into different work packages/ contracts) and horizontally (in terms of operations such as earthworks and surfacing) was also recommended;
(b) rationalisation of the previous system of registration, grading and prequalification of contractors;
(c) extracting the funding component envisaged for equipment from a series of projects under the new ADB programme; and using it to procure a centralised equipment pool that would service a number of domestic contractors, each handling a 'reasonably' sized work package and having their own less capital-intensive core equipment and expertise;
(d) enforcing the World Bank (1992) and similar Asian Development Bank guidelines for a 7.5% preference margin for domestic contractors in developing economies; and
(e) consideration of alternative Conditions of Contract, including the New Engineering Contract.

The foregoing case study reinforces the contention that appropriate 'work packaging' contributes critically to longer term industry development (and project performance) strategies.

TOWARDS A TECHNOLOGY EXCHANGE PARADIGM

Despite assurances or even stipulations in Joint Venture and other procurement agreements - targeted technology transfers have rarely been attained in the construction industry, as described by Simkoko (1995) and explained by Carrillo (1995). Kumaraswamy (1995) proposed an alternative paradigm of 'technology exchange' as being more likely to attract the attention of potential partners and that may therefore be more viable.

The conceptualisation of technology exchange is based on the holistic framework of technology formulated by the Asia Pacific Centre for the Transfer of Technology (1989). This framework incorporated the 'softer' components of 'Inforware' (Document-embodied facts), Orgaware (Institution-embodied frameworks), and Humanware (Person-embodied abilities) in addition to the more visible ‘harder’ component of ‘Technoware’ (Object-embodied facilities). An evaluation system was developed in parallel, to assess technology levels in relation to each of the four foregoing components and to present them in the form of an organisational ‘technology profile’.

Figure 2a illustrates the juxtaposition of the technology profiles of two organizations A and B, together with the projected synergistic potential of a Joint Venture between A and B - that complements the weaknesses of one with the strengths of the other. For example, more meaningful and viable partnerships can be based on a blending of the organisational ‘knowhow’ and human resource pools of a local partner - with the equipment-related ‘knowhow’ and international/ technical information networks of a foreign partner.

Selecting appropriate Joint Venture Partners

Kumaraswamy (1997c) proposed a basic model for appraising potential partners in terms of their short and long term objectives, resource pools and compatibilities. This was demonstrated by using a flowchart; sets of criteria, sub-criteria and indicators to be considered; and a diagrammatic representation. The latter has been developed further in Figure 2b to incorporate comparisons of relative strengths against:

(A) four basic criteria of (1) financial strength, (2) organizational experience, (3) personnel and (4) technology;
(B) chosen sets of sub-criteria, such as those for 'technology' as considered earlier; and
(C) more detailed consideration in terms of typical sub-sub-criteria of for example, the four technological sub-criteria considered previously.

Achieving synergistic profiles between potential partners may thus be targeted in respect of relevant criteria (such as finance, experience, personnel and technology), of chosen project-specific (and/ or industry-specific) sub-criteria (such as technoware, orgaware, inforware and humanware, in respect of the ‘technology’ criterion for example) and of selected sub-sub-criteria (such as availability of specific construction plant, tools, automation levels and productivity levels - in respect of the ‘technoware' sub-criterion).

While carrying out such modelling in a given scenario, it may even become apparent that more than two partners are needed to meet all the required needs. In such cases an appraisal is useful to ensure that the benefits exceed the ‘costs’ of co-ordination. An alternative approach may of course make the third party a sub-contractor to one of the partners, particularly if the complex organisational structures and interface management problems in a multi-party consortium appear to be too daunting.

The multiplicity of variables - including selection criteria and information sources - that need to be considered in such appraisals, point to the need to harness the growing power of Information Technology and knowledge-based (and even Artificial Intelligence supported) systems in structuring, assembling interpreting and drawing on relevant databanks.

INFORMATION NEEDS - FOR REPACKAGING AND MANAGING MEGAPROJECTS

Improving Procurement Systems

The foregoing sections conceptualised the re-engineering of ‘work packaging’ and other aspects in assembling appropriate procurement systems, as well as of a more meaningful ‘technology exchange’ in Joint Ventures and other project participant interactions. Proper implementation presupposes the collection and codification of historical data, for example from past projects, thumb-rules/ heuristics from experts and project participants, as well as ‘real time’ data relating for instance to client needs and priorities in both the short and long terms, the current contextual conditions of the present project and the industry, together with detailed information on potential project participants.

Kumaraswamy (1997a) proposed an integrated knowledge-based decision support system with an ‘expert system’ front-end to assist (a) in modelling the priorities and contextual conditions in each project scenario; and (b) in assembling an appropriate procurement system to suit such a scenario. Figure 3 illustrates the proposed structure of such a client advisory system, that would necessarily draw on databanks/ knowledge-bases (including both data and heuristics) as discussed in the preceding paragraph. Admittedly, a formidable volume of data needs to be collected and processed before the relationships between various project performance criteria and different procurement sub-system options may be more meaningfully modelled (Kumaraswamy and Dissanayake, 1996). Meanwhile, expert opinions may be substituted to help reach ‘better than usual’ decisions on appropriate procurement systems. No exact/ perfect solutions are envisaged in either case, although much-better-informed and improved decisions are expected to follow.

A further dimension needs to be introduced into the selection system, in the context of the thrust in this paper to accommodate long-term industry development objectives. Thus decision makers on public-funded (or largely public- funded) megaprojects need to achieve a balance between short-term project performance criteria (for example, sacrificing a degree of project speed and/or managerial convenience) and longer term industry development needs (for example, by encouraging domestic /Joint Venture partners/ sub-contractors. The latter would arguably lead to more economical and conveniently procured projects in the longer term, as well.

Improving Managerial Systems

However, an ongoing investigation based in Hong Kong collaborates the findings of previous researchers - such as Walker (1995) and Rwelamila and Hall (1994) for example - that project performance outcomes are not determined by the choice of an appropriate procurement system alone. While the latter certainly contributes to performance levels, and more so when the selection of suitable project participants is considered to be a part of the procurement system as in this paper, other factors - such as those relating to eventual team interactions and overall management, including information management and responses to external conditions - also play a significant role in determining success/ failure levels.

Managerial systems thus themselves need to be re-examined and revamped and this is, perhaps ironically, partly due to the opportunities opened up by Information Technology (IT), while IT itself can be extensively harnessed in such revamping.

For example, even in general non-construction management, a group of contemporary management ‘gurus’ recently called for a ‘renaissance’ in rethinking organisational structures and management styles (Gibson, 1997) to better exploit the exploding information /communications technologies, growing globalisation and the many new ways of interacting and working together.

Kumaraswamy and Thorpe (1996) demonstrated both the need and potential for harnessing information from the monitoring and evaluation of ongoing and completed construction projects - in order to ‘learn lessons’ that would help improve construction project management systems and approaches. The recommended evaluation system also incorporated knowledge-bases with an ‘expert system’ front-end. Information Technology inputs are again needed in assembling, interpreting and transmitting such evaluations; and in linking them to the proposed procurement selection advisory system as well, so as to enhance the sensitivities of the latter to the effects of other variables.

CONCLUSIONS

The proliferation of procurement options have increased pressures for appropriate choices, even more so in megaprojects in developing countries - where the short term performance requirements should be balanced against the needs for longer term industry development. Even in developed countries, performance-oriented procurement systems can be targeted on the basis of more informed procurement decisions and longer-term industry development.

Suitable packaging of megaproject work, for example in terms of 'optimal' package sizes, types and locations; and ‘operational’ ‘functional’ and ‘resource provisions’ differentiation is a crucial component of appropriate procurement. The selection of suitable Joint Venture partners and other project participants is also critical to successful procurement. Strengths and weaknesses of different participants may be ‘synergised’ through conscious efforts at two-way ‘technology exchange’, rather than the often futile pursuit of one-way technology transfers.

Management systems, need to be upgraded in parallel, so as to reap the benefits of appropriate procurement. Linkages to comprehensive project monitoring and evaluation systems are in turn needed to upgrade the quality of management itself, so as to enhance project performance levels.

The foregoing needs - for better 'informed' procurement and management systems as conceptualised in this paper - can only be adequately met by mobilising Information Technology systems and tools to assemble, analyse and interpret the proposed databanks and knowledge-bases. The proposed frameworks provide a suitable skeletal/ structural system that must be 'fleshed out' by feeding in information from recent projects and industry experts, to develop the required databanks and knowledge-bases.

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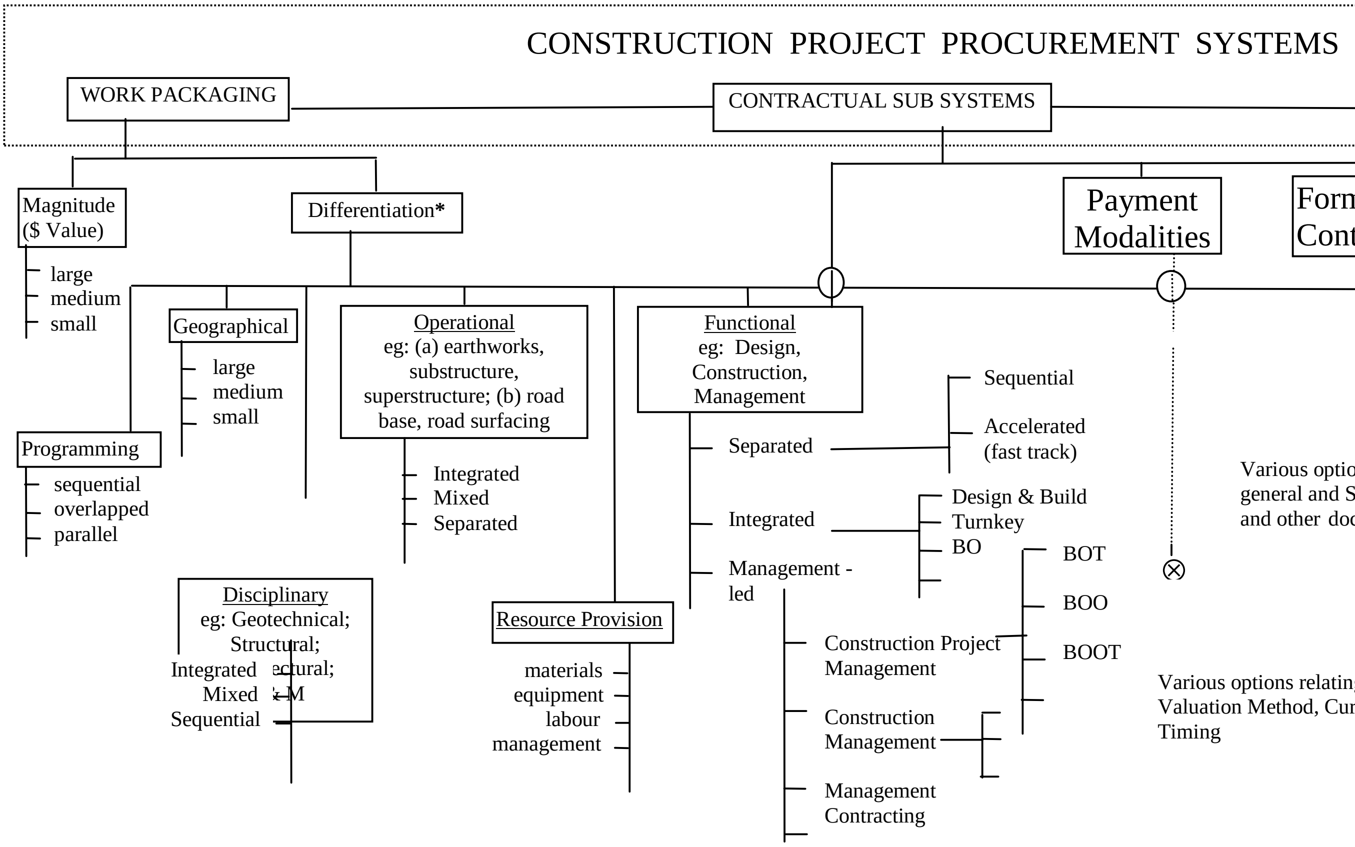


Fig. 1: Work Packaging Options in Construction Procure

Notes

* Some or all of these types may apply depending on the project. Some overlap is possible eg: between (but not always).

∇ Further differentiation is possible in terms of (a) countries of origin eg: (only donor/ shareholders eligi capacities of the organizations, as may be determined by the other branch of the selection methodologi prequalification

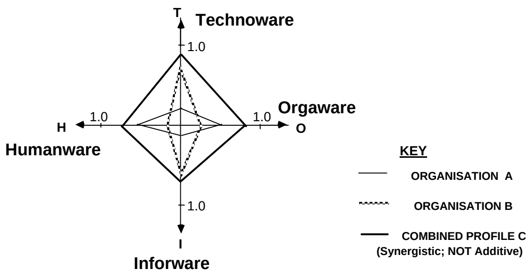


Figure 2a: Synergising Technology Profiles of two Organisations

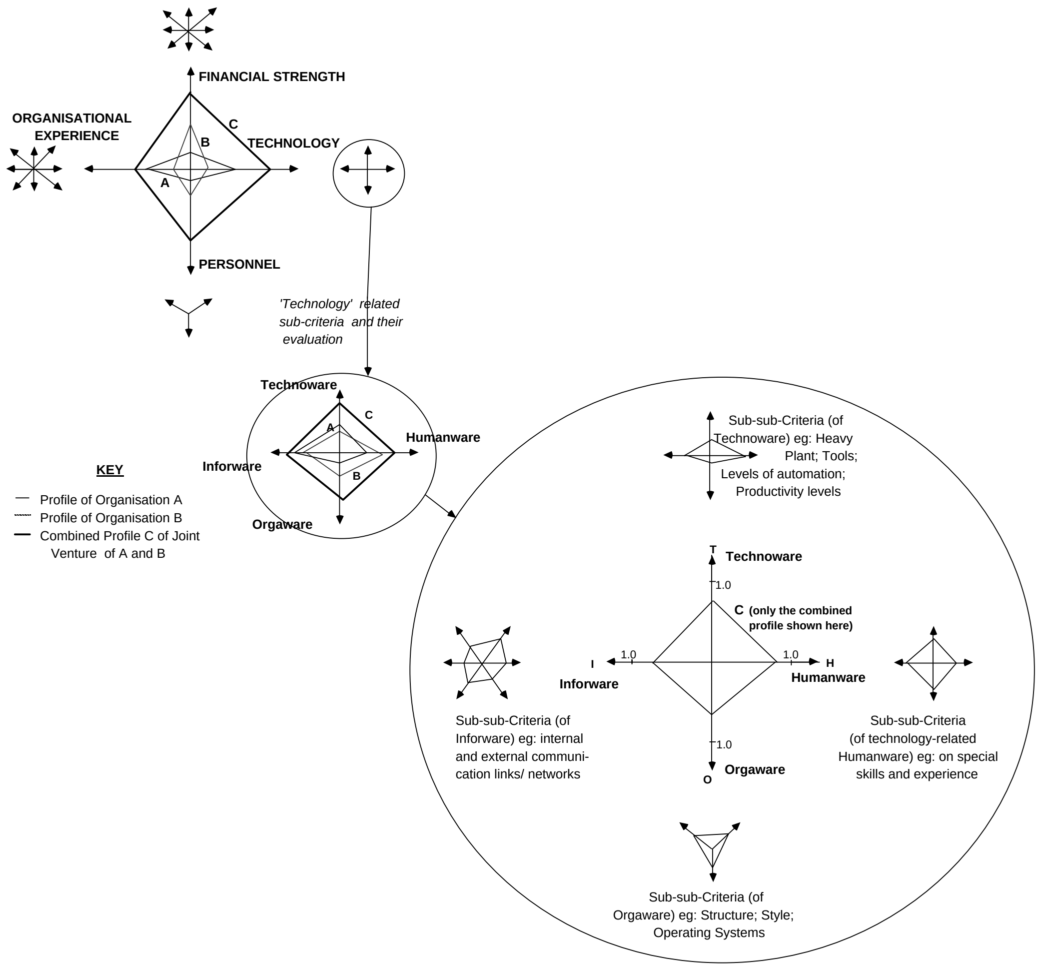
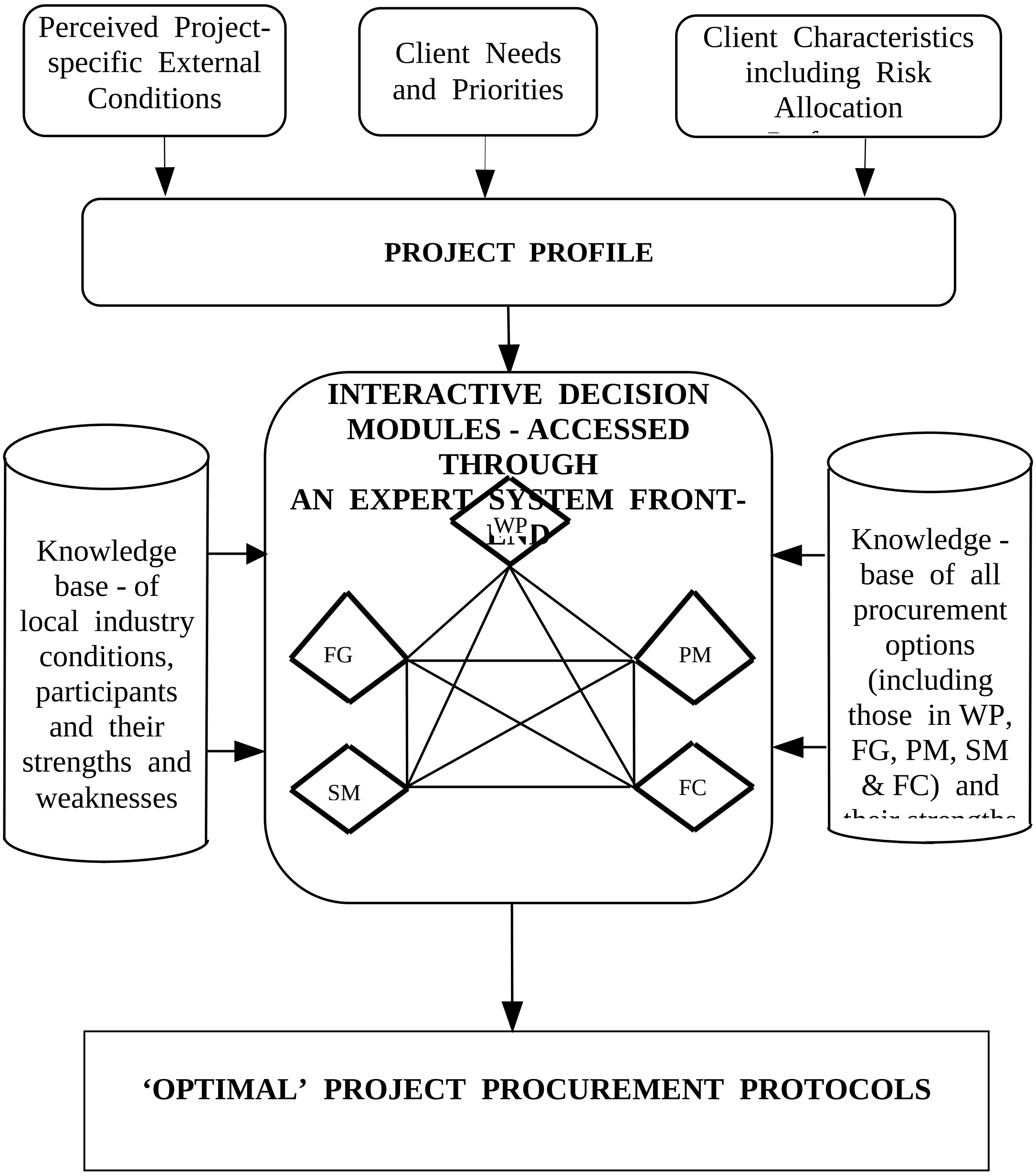


Fig. 2b: Evaluating the Synergistic Potential between two prospective partners - in relation to more comprehensive Criteria, Sub-criteria and Sub-sub-criteria



ABBREVIATIONS

FC - FORM OF CONTRACT
FG - FUNCTIONAL GROUPING
PM - PAYMENT MODALITIES
SM - SELECTION METHODOLOGIES
WP - WORK PACKAGING

Fig. 3 : Proposed structure of a Client Advisory System for Optimizing Procurement Protocols