nstruction Industry Development

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Abstract

The needs for construction industry development are initially viewed from the broader perspectives of imperatives for infrastructure development and national development. All these are clearly more critical in developing countries. A non-exhaustive set of potential drivers and common barriers to construction industry development is identified from previous research. These suggest the usefulness of consolidating a cluster of recent proposals and exercises aiming at (a) construction organisation development in terms of an over-arching management support system model, as well as improved information and knowledge management; and (b) project team development in the context of relationally integrated teams and supply chains, joint risk management and 'technology and knowledge exchange' in joint ventures, as well as longer term public private partnerships. These apparently disparate research thrusts are threaded together into a pattern that may inspire, if not feed, specific research and development (R&D) agendas for construction industry development in different countries according to their own priorities, constraints and stages of infrastructure and national development.

Keywords

Construction industry, Development, Infrastructure, Relational, Sustainable, Technology

INTRODUCTION

Growing problems in construction industries have spawned a spate of reports in the last decade. For example, these recommend drastic improvements in the construction industries of supposedly developed countries/regimes including the UK, Australia, Singapore, Hong Kong and the Netherlands (Egan, 1998; CIRC, 2001). Some of those lessons learned, corrective strategies and their success levels are worth visiting when formulating development agendas for developing countries, which of course each have their own general and country-specific concerns and constraints. Still, these "bigger" barriers may be approached with this "better" knowledge; and secondly globalisation has accelerated the diffusion of theory and practice; while thirdly developing countries should arguably have opportunities to show much higher gains, given their presumably much lower starting levels. Of course they must identify specific strategies to suit the situation in each country.

This paper aims to initiate what could be a useful framework and also a knowledge-based for the above – by weaving together a series of research threads and packing together some pockets of knowledge in terms of potential drivers and common barriers to construction industry development. A couple of caveats are in order at the outset:

a. all possibly important drivers and barriers are not covered

b. given the wide range covered in any case (e.g. from developing industries to organisations and project teams), this paper is not self-sufficient in detailing, or indeed justifying all that is presented, with research methods used, detailed findings and complete literature reviews in each area. However, references to previous documentation of feeder research exercises are provided for readers interested in delving deeper into particular aspects.

A broad-brush overview first provides a fresh conceptualisation of the broader context of construction industry development (CID) in the next section; outline models illustrate a set of research thrusts into organisational management support systems and project procurement and team-working improvements, in the next two sections;

eys are provided in the following section on technology exchange e" (TKE). TKE expands on the previously proposed concept of TE which encouraged mutual benefits through "two-way" cross-transfers of different components of technology hardware and software between joint venture partners (Kumaraswamy, 1998). The proposed TKE expands this concept to include knowledge, where each party can share special knowledge that can benefit the project and extend it down the construction supply chain in both the short-term project and the long-term projects, e.g. in sustainable infrastructure and public private partnership (PPP). The concluding section refocuses on the common CID objectives and features of the foregoing research initiatives, and proposes a platform for launching a cluster of interlocking R&D projects that could identify the strengths of some developing countries (e.g. traditionally relational cultures), special needs and limitations (e.g. corruption) to be addressed in different regimes, elicit country-specific drivers, enablers and barriers to CID, and generate their own action agendas therefrom.

CID, INFRASTRUCTURE DEVELOPMENT AND NATIONAL DEVELOPMENT

Advocating CID for its own sake may seem somewhat selfish, specially if it incorporates unsubstantiated pleas for government spending to sustain employment levels when construction projects are scarce. For example, van der Kamp (2003) argued that "spending to create jobs." However, sensible cases have been made for redeploying trained construction personnel for renewing ageing infrastructure in times of low new workload, for example. That there is a need for infrastructure renewal in developed countries is being increasingly highlighted, e.g. in the deplorably low "scores," revealed in infrastructure 'report cards' compiled by the American Society of Civil Engineers (ASCE, 2005) and Engineers Australia (Pinzone, 2005), to convey the current state of their national infrastructure. The infrastructure was categorised into various types, such as aviation/airports, bridges, dams, drinking/potable water, electricity, gas, public parks and recreation, mass transit, wastewater, hazardous ways, navigable waterways, stormwater, irrigation, ports, rail and roads. Specific scores obtained by various infrastructure types were generally quite low, with some in Australia noted to be in "a disturbing state requiring immediate attention" (Pinzone, 2005). Ten out of 14 being in the "D range" (signifying "poor") in United State of America (ASCE, 2005), on a scale from A (excellent) to D (poor) with the next level being 'F' "failing"!

While the needs and dynamics are necessarily different in developing countries which are yet painstakingly building up their basic infrastructure stock, lessons may be learnt in planning and designing for more sustainable infrastructure. This calls for a healthy and knowledgeable construction industry by itself, while an efficient and effective industry is needed to produce the most from limited resources. This in turn translates into the urgent needs for knowledgeable and efficient construction organisations and practitioners.

On the other hand, under-developed construction industries could easily squander limited funds, produce unsustainable infrastructure and plunge nations into a downward spiral of dumping more money for early replacement/renewal of urgently needed facilities. Of course such scenarios are sometimes aggravated by corruption that distorts the planning and procurement processes, and that put rapid personal profit well above public interest.

The linkages between CID, infrastructure development and the broader role of national development (the ultimate goal being global development!) are too many and complex to explore in this paper, and better left to construction economists. Drewer (1980) drew attention to "a reasonably well-defined relationship between construction output and the level of development, and indications of positive correlation between per capita value-added by construction and per capita GDP," while Tse and Ganesan (1997) investigated lead-lag relationships between construction activity and the Hong Kong economy, identifying how governmental macroeconomic policy affects outputs and influences construction activity.

From the viewpoint of developing construction industries in particular, Drewer (1990) highlighted how companies and practices from developed economies dominated contractor activities in many developing nations, through providing consultants, contractors, equipment and even materials. Kumaraswamy (1994, 1998) drew on a

...or, to demonstrate potential generic problems when megaprojects ... "aid" or financing packages. This highlighted the ironical 'chicken and egg' (or 'Catch 22') dilemma of (a) arguably not being able to give domestic (indigenous) contractors work because of their allegedly inadequate experience capacities, while (b) these contractors can hardly develop their experience/capacities, unless they are provided opportunities for such work. Sri Lanka for one, paid inflated project costs driven up by foreign contractors, even for parts of the work that could have been easily handled locally, and were in fact often eventually handled locally – after subcontracting at much lower rates to the locals! Even the few joint ventures (JVs) were often nominal – usually formed for increasing their chances of prequalifying for certain projects, after the government and some multilateral agencies began to encourage JVs, or for securing the 7.5% tender price preference margins for domestic contractors in developing economies then available on some World Bank or Asian Development Bank funded contracts (World Bank, 1992). More recently, "Action Aid" reported that 60% of aid money was wasted on "phantom aid flows" such as paying for expatriate lifestyles of consultants (ICE, 2005).

Also, (a) Abdul Aziz and Ofori (1996) found that government procurement policies impacted significantly on the development of domestic contractors in Malaysia; while (b) Ofori and Teo (1996) traced the role of appropriate procurement policies in developing the construction industry in Singapore; and (c) Gounden (1996) outlined the 'Procurement Reform Initiative' being implemented in South Africa to increase participant capacities, output and competitiveness.

Overall, one can justifiably generalise more recent relevant observations by the South African Minister of Public Works (Sigcau, 2003), e.g. (a) "the (South African) construction industry is a national asset in the strategy to achieve economic growth and improve the quality of life of the majority of South Africans. Therefore, our role as government is equally clear – and over the past few years we have worked relentlessly to facilitate an enabling framework for industry growth and transformation;" and more broadly (b) "construction creates the foundations of our global economy. In one way or another it underpins every advance made by humanity…"

Drawing on the above clusters of knowledge, what may be considered a somewhat simplistic summary model is conceptualised in Figure 1 (as developed for this paper) to provide an overview for purposes of this paper, as well as for future development and operationalisation. Some of the "drivers" and "barriers" shown in Figure 1 are discussed in this paper, while others are self-explanatory and/or have been discussed at length in the literature already. Also, when developing this model later, a distinction may also be drawn between "drivers" and "enablers"/"facilitators" etc., but the present broad-brush overview enables the strategic conceptualisation envisaged in this paper.

The need to incorporate some of the barriers shown in Figure 1 should be self-evident. For example, those on cultural mismatches have been extensively researched and documented. On the other hand, cultural synergies through integrated teams may also be derived (Kumaraswamy et al., 2002), to reverse the latter and even develop drivers, e.g. by mobilising concepts of collective cooperation originating from different parts of the world. These could include *ubuntu* (a broad concept, embracing collective unity and morality) from Africa (Rwelamila et al., 1999; Rwelamila and Khumalo, 2002); *gotong-royong* (togetherness) and *musyawarah mufakat* (achieving a consensus decision) from Indonesia (Tjandra, 2004); similar concepts from Japan such as *amae*, *ringi* and *keiretsu* indicating inter-dependence through informal support networks, joint decision making and inter-linking of several organisations through production networks and long-term relationships; and the Chinese concept of *guanxi* (good relationships, and indeed getting things done through such good relationships).

Furthermore, one cannot ignore (ostrich-like) the scourge of corruption that siphons the lifeblood of development. Organisations like Transparency International (2002) have highlighted some of the general problems and impacts; while those specific to construction are also receiving attention, e.g. by the ASCE which issued a recent report (ASCE, 2005b) setting out guidelines to reduce corruption in the engineering and construction industry, and proposing policies to encourage "zero tolerance" for bribery. Of course, much still remains to be done to address this major barrier in many countries.

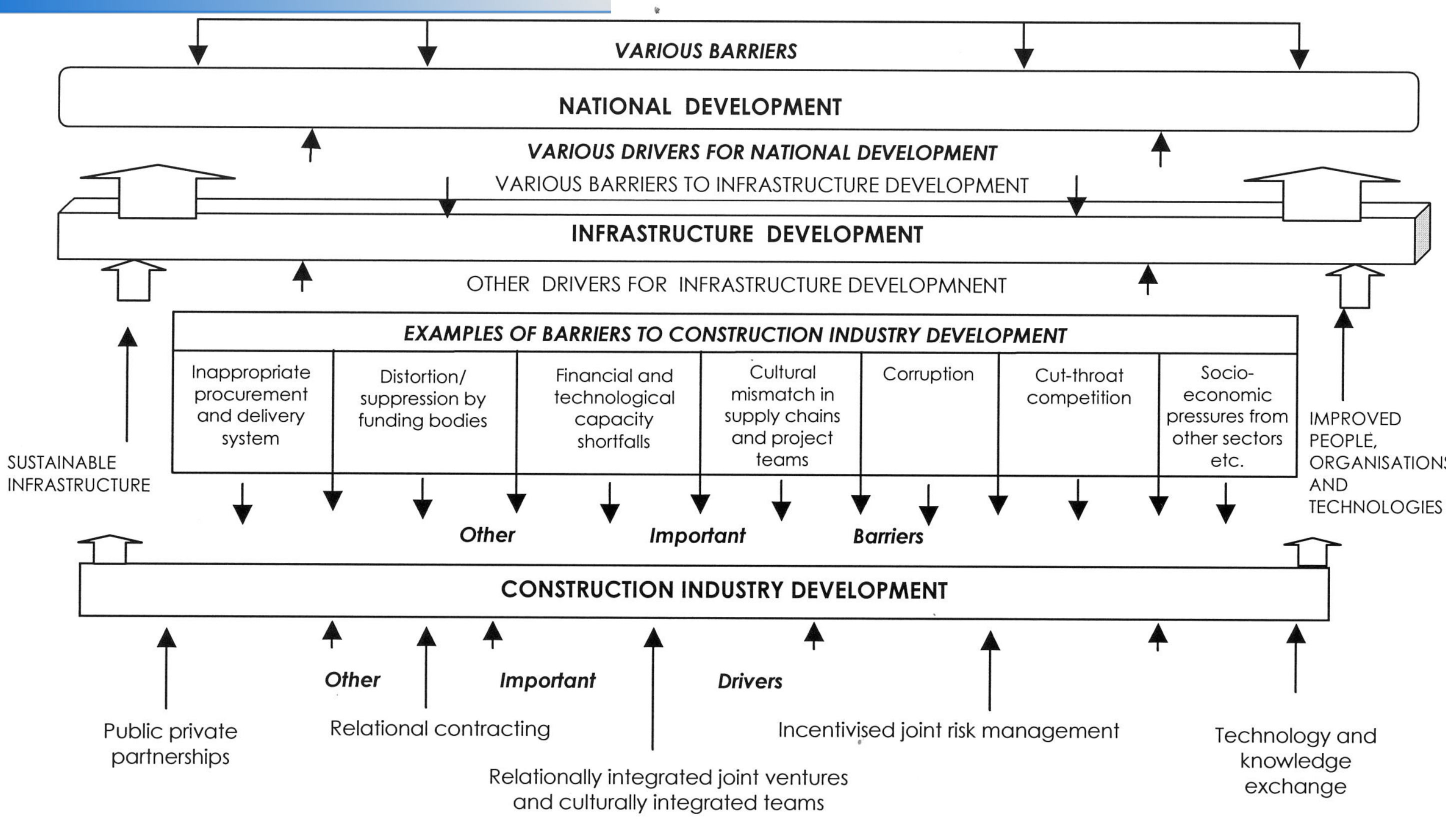

Figure 1. Targeting Construction Industry Development:
Basic Framework for Identifying Drivers, Barriers and Linkages

ORGANISATIONAL MANAGEMENT SUPPORT SYSTEMS

CID must necessarily include the development of construction organisations, ranging from large clients to small subcontractors and material suppliers. Two on-going R&D projects based in Hong Kong target both top-down and bottom-up improvements across construction supply chains (Kumaraswamy et al., 2004a). These address the "procurement and delivery systems" barrier seen in Figure 1.

It may be mentioned that the Hong Kong construction industry provides a good testing ground for such advances, given the intensity and extent of infrastructure development, that has attracted construction organisations from many other countries. This also results in close linkages to international developments, for example facilitating the rapid exchange of ideas and practices pertaining to innovations in construction project management and technologies. However, the public sector is seen as rather slow to adopt innovations themselves, as in many other countries, given the needs for convincing justifications (before deviating from traditional practice) and strict accountability. On the other hand, the private sector and the quasi-government sector (including the railway corporations) have been proactive in rapidly taking on board innovative approaches e.g. in partnering.

Management Support System (MSS) for Large Construction Clients

This R&D project aims to develop (a) rich knowledge-based of sound principles, and best practices and innovations, in optimising selected construction procurement and operational/delivery subsystems, in the context of both client priorities and project contextual conditions; (b) an MSS framework; and (c) prototype working modules – to provide

...on aids in some sample areas, e.g. (i) in incorporating "relational ...tnering and alliancing arrangements in construction projects, (ii) contractor selection, and (iii) public private partnered procurement.

An integrated MSS is proposed, since both general systems theory and specific research into performance-oriented procurement systems (Kumaraswamy, 1998) indicate the need to target an optimal balance between all related systems and subsystems simultaneously. Figure 2 depicts four primary systems that should assist in the long- term development of a large construction client. These include institutional, human resource and technological development – to deal with continuing multiproject portfolios. The complexities of the multiple short- and long-term performance goals suggest the need for an information and communication technology – artificial intelligence (ICT-AI) enabled over-arching MSS to synergise optimising decisions in each system, rather than to generate conflicts, e.g. through a delivery system that is incompatible with a chosen procurement strategy.

The need for longer term human resource and technological development systems are identified as in Figure 2 that was conceptualised for the above MSS project (Kumaraswamy et al., 2004b), and are briefly addressed in the penultimate section of this paper. It may also be noted that interorganisational learning systems would include cooperative learning alliances (Kumaraswamy et al., 2001) and overall knowledge capture, enhancement and sharing strategies (Love, 2002).

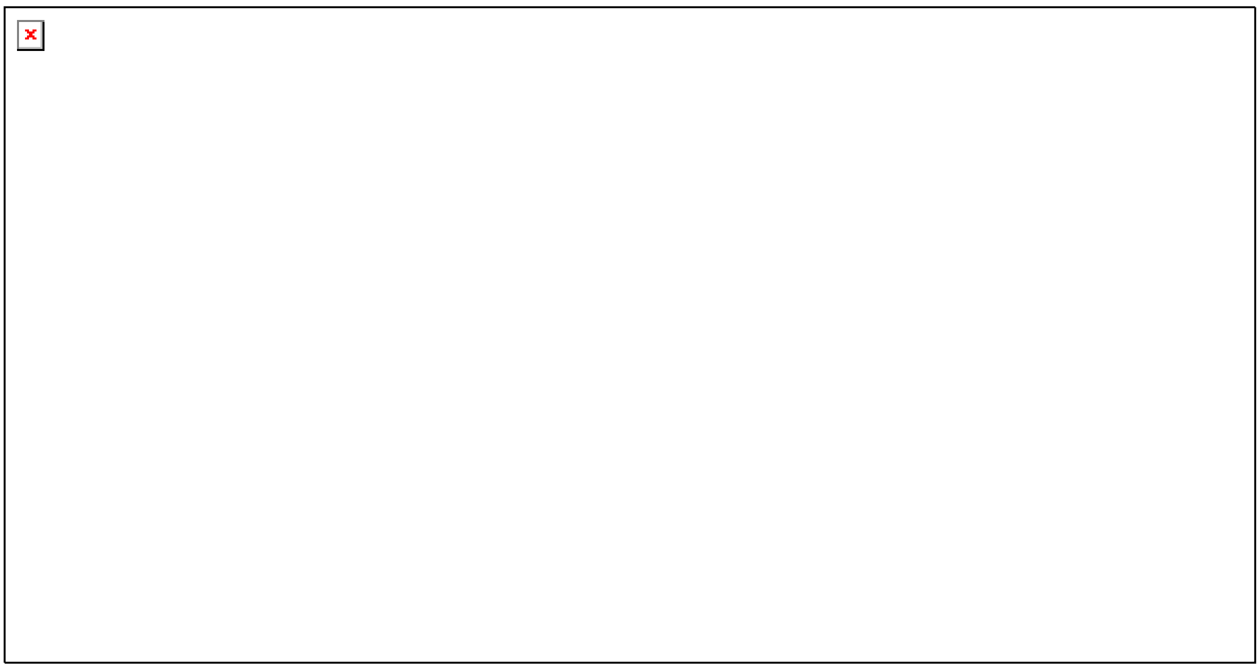

Figure 2. MSS Model for Collaborative Construction Project Decisions

Procurement is taken to include five upstream strategic subsystems, while "delivery" encompasses the downstream managerial/operational subsystems, shown in Figure 3. For example, in the procurement system: after the front-end demarcation of a mega-project into work packages (WP), the functional grouping (FG) involves decisions on whether the design, construction, project management and financing (and various components of all these functions) are handled separately by different organisations, or integrated to different degrees, e.g. in different types of design and build, PPP, or management contracting systems. More information on these and other aspects is available in Kumaraswamy (1998) and Kumaraswamy et al. (2004b).

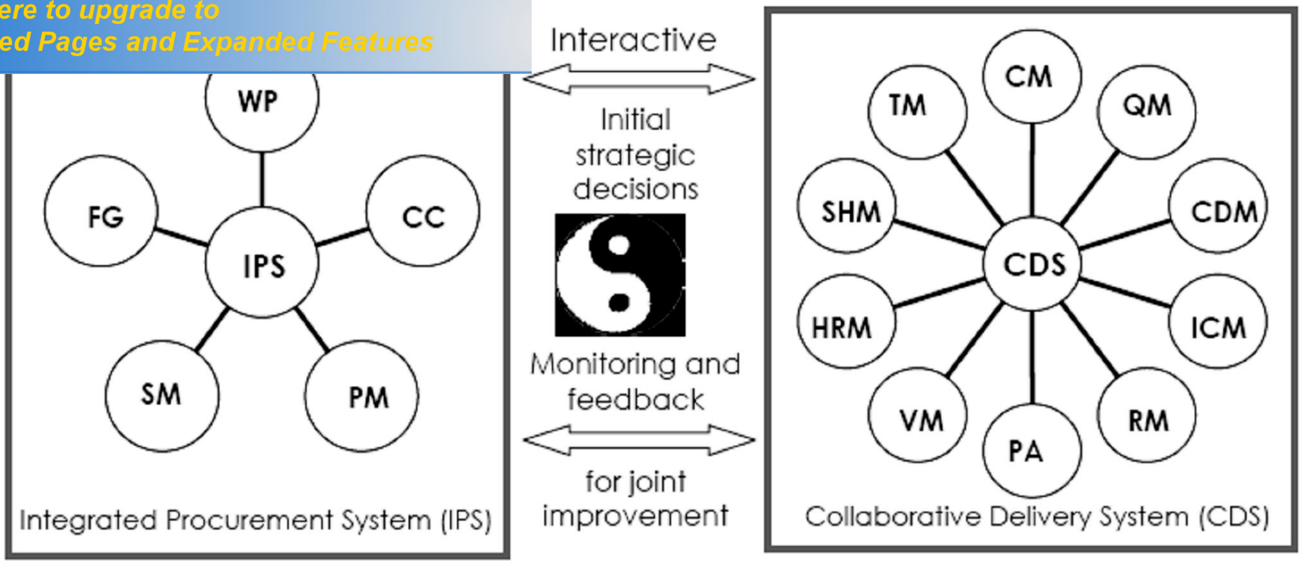

Figure 3. Collaborative Procurement and Delivery Systems in Proposed MSS

Information and Knowledge Management System (IKMS) for Small and Medium Contractors (SMCs)

This other on-going R&D project aims at "bottom-up" improvements through the construction supply chain by the development of small and medium contractors (SMCs). This involves developing a "SMC-friendly" framework and innovative tools for boosting productivity, quality and image, through strategic information and knowledge management (IKMS). For example, savings are envisaged through opening up more "business knowledge," commercial choices and opportunities in general, more efficient and timely information flows, reduced wastage and less rework.

Although focussing on SMCs, it is deemed useful to involve other members of the supply chain, including the bigger contractors, consultants and clients. Still, the initial target group of SMCs form the "back-bone" of the construction industry in most countries, and more so in developing countries, where they also proliferate in both formal and informal subsectors.

More information on this Hong Kong based project is available in Kumaraswamy et al. (2004a). This particular project aims to provide:

a. a web-based information library for boosting SMCs' business and operations. This will include information on new technologies, business opportunities and innovative approaches for SMCs,

ge management framework that captures (and makes easily
tion and business process knowledge,

c. a "strategic information and knowledge manager," which will be an SMC-friendly affordable business and operations support-cum-advisory system for SMCs,

d. templates and initial issues of periodical (e.g. quarterly) newsletters/e-bulletins on useful SMC matters, and

e. a basic training and workshop package and a self-learning package to enable quick and effective usage of the above deliverables.

RELATIONAL CONTRACTING AND RELATIONALLY INTEGRATED TEAMS

Barriers from Traditional Approaches and Classical Contracting

Some of the major root causes of problems that are repeatedly revealed in reports on the construction industries in developed countries are the traditionally adversarial procurement strategies and contractual systems (Egan, 1998; CIRC, 2001). These foster distrust, spawn extra layers of "checks," diverting resources from actual productive work, and breed claims and disputes. All this in turn generally results in waste, time and cost over-runs, lower quality and other problems, as each "group" focuses on its own interests, e.g. maximising its own outputs and minimising its own inputs, rather than on common project objectives and on optimising overall productivity.

Furthermore, many clients have been risk-evasive under classical contract regimes. Also, their contractor selection strategies have been mainly price-based, hence fostering the "cut-throat competition" barrier highlighted in Figure 1. This often results in poor performance, as well as a neglect of safety, environmental and whole-life considerations which would have otherwise increased tender prices, but led to more realistically costed and sustainable infrastructure. The needs for broader selection criteria, optimised construction supply chains and smoother interorganisational transactions have been highlighted by many practitioners and researchers, including Kumaraswamy et al. (2000) and Palaneeswaran et al. (2003).

Many developing countries have unfortunately had such adversarial systems imposed on them by their erstwhile colonial masters in many cases, contrary to their own cultures, that embodied collaboration, interdependence and mutual support, for example as indicated in the Eastern concepts of *guanxi, gotong-royong* and *amae*, and the African concept of *ubuntu* as described in the second section of this paper. Ironically, many developed countries are now striving towards collaborative modes of procurement and contracting, e.g. as in partnering and alliancing; while many developing countries now seem unsure of the right balance to be achieved. The latter is aggravated by the perceived uncertainties and increased exposure to corrupt practices if contractual risk allocation, roles, rights and obligations are not clearly defined.

Need for Relational Approaches

In addressing the above barriers, one cannot ignore the massive shifts towards more "relational" contracting modalities and the greater reliance on better relationships to achieve construction project goals in developed countries. In justifying such a move in developing countries: (a) in principle, relational contracting (RC) theory (Macneil, 1974) provides a sound basis for this shift from a traditionally adversarial system; while (b) the practical benefits are seen in (i) a major realignment towards "common objectives" and "partnering" approaches in general; and in (ii) injecting a healthy dose of joint risk management (JRM), over and above traditional (classical and neo-classical) contracting and risk allocation principles (Rahman and Kumaraswamy, 2002). Furthermore, RC principles and incentivised JRM practices (e.g. incorporating pain-share/gain-share incentives) can empower proactive contracting and project delivery strategies, e.g. by suitably "incentivising" designers, contractors, subcontractors and suppliers towards a longer-term mind-set; e.g. towards broader environmental, deeper durability and "whole-life" u et al., 2003b).

Specifically, RC provides a sound basis for reducing the formal transactions, friction and disputes (Rahman and Kumaraswamy, 2002), e.g. by focusing on "common objectives" including value for money (rather than just low price). The need for such a shift is highlighted by many studies that underline the importance of cooperation for project success (Phua and Rowlinson, 2004).

That RC is valuable for the above has been confirmed by a well-structured series of Hong Kong based surveys, reported by Rahman and Kumaraswamy (2004). Collaborative working practices (including pain-share/gain-share incentives) that have been developed in some key infrastructure projects in Hong Kong also reflect such emerging views, as were discussed at a recent industry conference (Lighthouse Club, 2004).

Project stakeholders should work in more integrated teams and supply chains, so that their joint decisions could better target the broader and longer-term overall organisational objectives. RC can thus legitimise such integrated teams, that had been urged in high powered recommendations to industry, both in Hong Kong and elsewhere (CIRC, 2001; Strategic Forum, 2002). Of course, some precautions are necessary, e.g. against delayed decisions and/or abuse in implementation. For example, short-sighted and/or greedy "partners" may seek to abuse good relationships and secure unfair advantages or exorbitant profits.

Relational Integration for Project Teams, Supply Chains and Effective PPPs

In summary, traditional/classical contracting strategies are often blamed for adversarial force fields that push project participants apart, as in Figure 4. Valuable time and resources are wasted on managing cross-organisational interfaces, and resolving disputes on contractual responsibilities and liabilities. It is seen that the natural "push" forces (pushing contracting parties apart) are strongly reinforced by the traditional procurement and classical contracting strategies, thereby overcoming the weaker pull forces in this scenario.

Relational approaches could well extend beyond just one project and foster more "sustainable" relationship. For example, through the "framework agreements" of the British Airports Authority, "preferred contractors" or "premier league" arrangements of other clients (as tried by the Hong Kong Housing Authority), or even less formal arrangements that clients with large and continuing construction project portfolios (such as in the housing, health and defence subsectors, or in the case of supermarket chains) can develop with selected contractors (and indeed consultants and major suppliers). Such arrangements enable a client to choose contractors (and other project team members) for each specific project from a shortlisted group that is familiar with its specific needs and priorities. This then reduces misunderstandings and transactional friction between project team members who have interacted, if not worked together before. This in turn reduces overheads, rework and therefore overall costs. Furthermore, contractors, consultants and suppliers who foresee a reasonably continuous volume of work of a certain type (e.g. in power plants, supermarkets or hospital buildings i.e. with a client with whom they have such arrangements) would be readier to invest in technologies and specialist personnel (including special training), that could further reduce overheads and unit costs over the long-term.

Kumaraswamy et al. (2005) showed how RC approaches could help pull together team members as in the lower part of Figure 5 (who may have been otherwise pushed apart by classical contracting approaches as in Figure 4, or the upper part of Figure 5). They expanded this concept (a) pulling together all team members into a relationally integrated total team; (b) developing more sustainable relationships for relationally integrated supply chains that continue their teamworking into other projects; and (c) consolidating relational contracting approaches and relationships across PPP teams whose life-span is necessarily longer, and who can then focus more clearly on developing sustainable infrastructure, which is in turn needed for national development.

Although space restricts expansion of the dangers and potential disadvantages of these approaches, it should be noted that RC approaches and PPPs do have limitations and can "backfire" if abused, or indeed if applied in inappropriate settings. For example, an unscrupulous contractor may abuse the trust of a client, or indeed of projects.

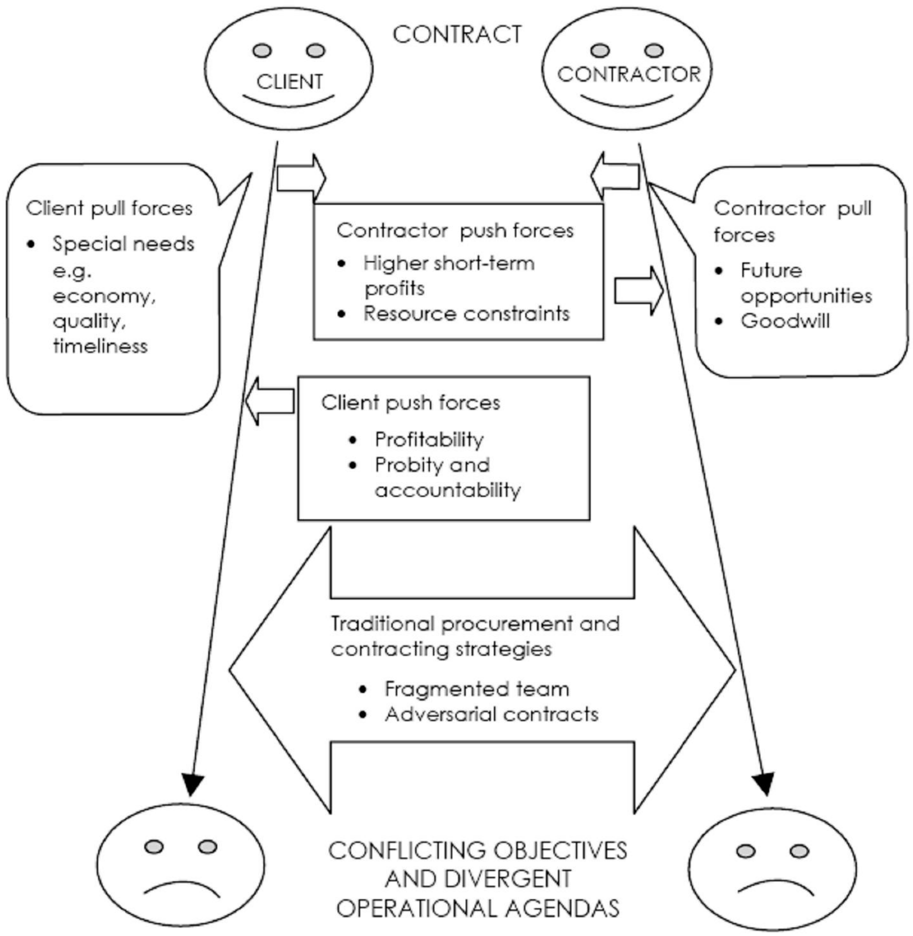

Figure 4. Force-fields Pushing Apart Clients and Contractors in Classical Contracting Scenarios

Figure 5. Comparison of Potential "Push" and "Pull" Forces between Any Two Team-members A and B

TECHNOLOGY AND KNOWLEDGE EXCHANGE IN SUSTAINABLE TEAMS

Improved relationships cooperation and trust in teams as targeted above, can lower the barriers and facilitate the exchange of technical know-how, as well as other knowledge. Synergistic technological systems were previously identified as one of the four important systems to be developed and integrated in organisational MSSs (as in Figure 2). However, it is impossible to achieve such synergies without building good relationships. Technology transfers (TTs) themselves have been advocated for decades as a way of boosting the technological capacities and the construction industries of less developed countries (Ofori, 1994; Simkoko, 1995).

However, high barriers to TTs have negated both the good intentions and even some contractual provisions that sought to ensure TTs (Carrillo, 1995; Kumaraswamy, 1995). This is not surprising, given the last facet of the CIB W107 developed definition of TT as, "TT has been said to have taken place where the receiver can use and adapt technology components on a self-reliant and sustainable basis in the construction/production processes; that the receiver has gained capabilities to adapt, maintain and even generate technology component more or less based on the originally received ones;" and that "in the end the receiver might be a competitor of the supplier" (Ofori, 2001).

This apparent lack of direct benefits to the suppliers of technology led Kumaraswamy (1995) to conceptualise a two-way process of TE, that could supersede the less attractive one-way TT. The TE paradigm was developed on the basis of the holistic model of technology proposed by the UNESCAP sponsored "Technology Atlas" project of the Asia Pacific Centre for the Transfer of Technology (1989). The base model postulated four basic dimensions/ components of technology as technoware (hardware and physical facilities), humanware (people and their abilities), infoware (documented facts) and orgaware (organisational networks and managerial frameworks). This model was projected in a basic "THIO diagram" representing the above four dimensions.

Kumaraswamy (1995) extended this basic THIO representation to show that some (not necessarily all)

...ed at any given time or on a given project. Secondly, technology ...e (or two) components may be transferred from party A to party B and vice versa. This reinforces the rationale of JVs where the strengths of one party compensate for the weaknesses of the other.

The overall integrated JV technology profile between two partners A and B can possibly expand to Y, as shown in Figure 6. However, inappropriate structuring of the JV functions, unrealistic resource demands and/or risk/reward mechanisms could diminish the integrated technology profile to X, i.e. to levels even below A's or B's in respect of particular technology components. A previous comparison of "integrated" and "non-integrated" JVs in Singapore, found that structural integration of the JV is crucial to JV success and continuity (Sridharan, 1994). Here, integration referred to the actual working together on specific WP, rather than compartmentalising and allocating each package to different partners, hence implying "structural" integration of the organisational and working arrangements.

Relational integration of the JV teams is also critical in creating a culture conducive to TE. This can start by first pushing organisations into a "knowledge sharing" mode to capture, develop and spread knowledge within the organisation in the first instance (Carrillo et al., 2003). Pushing them further to share knowledge with JV partners should then be easier than before, i.e. to migrate from an Intraorganisational to an interorganisational learning mode. Given the growing popularity of knowledge management, it is easier to link the broader visualisation of "technology" to the even broaer conceptualisationof "knowledge" that highlights the deeper and longer-term experiential facets. This should reinforce such exchange exercises further, hence the extension to TKE in this paper.

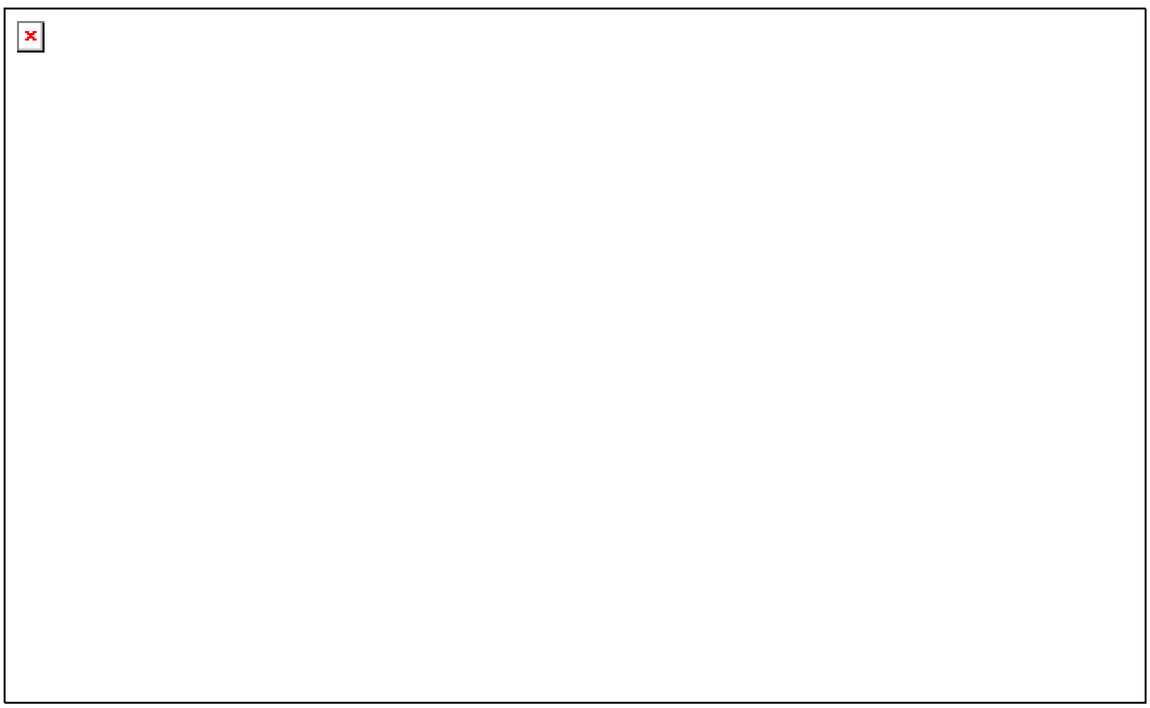

Figure 6. Two Potential Scenarios Of Overall (Combined) JV Capacities And Competencies

First focusing on TE, one of the obvious drivers should be the need for rapid development and deployment of synergies in JVs. A survey in August 2003 yielded the collective perceptions shown in Table 1 about the potential improvements from TTs and TE in Hong Kong JVs, as well as the potential usefulness to the organizations and industry. Table 1 summarises one important aspect of the 150 responses from professionals (mostly civil engineers) working for construction clients (36), for consultants (21), and contractors (93); the average total experience of the respondents being 11.9 years, and their average experience with/in JVs being 2 years.

cussed barriers), 68% of respondents perceived TT to be useful for industry; whereas only 42% felt it was taking place effectively at present. For this situation to improve, the many barriers to TT must be overcome. This particular survey also elicited interesting perceptions on "barriers to" and "drivers towards" TT. Although space does not permit reporting these here, they expand on previously identified barriers in an earlier pilot survey (Kumaraswamy and Shrestha, 2002).

Table 1. Perceptions of TT in JVs

	Perceptions	SA	A	DK	D	SD	Total
1	It takes place effectively now	4 (2.67%)	59 (39.33%)	34 (22.67%)	48 (32.00%)	5 (3.33%)	150 (100.00%)
2	It is likely to improve in near future	4 (2.67%)	85 (56.67%)	36 (24.00%)	25 (16.67%)	0 (0.00%)	150 (100.00%)
3	It is/can be useful for the company	11 (7.33%)	91 (60.67%)	29 (19.33%)	18 (12.00%)	1 (0.67%)	150 (100.00%)
4	It is/can be useful for the industry	18 (12.00%)	93 (62.00%)	23 (15.33%)	16 (10.67%)	0 (0.00%)	150 (100.00%)

Note: SA = Strongly Agree; A = Agree; DK = Don't Know; D = Disagree

This pilot survey in 2000, based on a small but experienced sample of 36 respondents, identified the top five barriers to TTs as organisational culture, lack of time, lack of capacity, individual attitudes and lack of clear policy. Even then, the need for TT between JV partners was seen to be high (with 83% of respondents agreeing) although the expectation of actually achieving benefits from TT was low (with only 50% agreeing), hence indicating the shortfalls in actual TTs achieved. Details of these other aspects, e.g. on the potential for increased organizational benefits, were reported by Kumaraswamy and Shrestha, (2002).

The third and even more recent Hong Kong-based study (Choi, 2005) in this series extended the TE concept to TKE as deemed feasible above, and carried out an interesting survey to test its acceptability to practitioners. The survey yielded 65 useful responses, with 19% being from public clients, 22% from consultants, 20% from contractors and 39% from subcontractors. This study also extended the application of TE/TKE from JVs to construction supply chains. The perceived value of TKE was clearly confirmed in this survey, with specific views derived in terms of each of the various components (T, H, I and O); and also the more detailed contributors/factors relating to each. For example, when taking all responses together, it was seen that 54%, 57%, 22% and 13% broadly agreed (breakdowns of degrees of agreement are also available) that TKE takes place now in terms of T, H, I and O respectively. This indicates less "exchange" of information and less interactions/integration of the partner organisations. Secondly, information on perceived barriers and drivers to TKE in particular were also elicited, e.g. 84% of respondents believed that the "cultural gap" between organisations must be addressed (relating to the "cultural mismatch" barrier Figure 1 in this paper). Thirdly, strategies for promoting TKE were also explored in what may be considered a preliminary venture into that domain. Unfortunately, space limits make it necessary for the results of this survey to be reported separately.

JVs provide a good starting point for building integrated teams; and are more suited for TE, given the presumably "equal" status of the base relationships, as compared to subcontracts for example. JVs are also increasingly common in construction industries, given the increasing complexity and magnitude of infrastructure projects that need diverse resource inputs from multidisciplinary teams.

The potential for TE and TKE through JVs is also supported by other studies, (a) Marcotte and Niosi (2000) who found that "tacit knowledge" is a substantial part of the TT from Canadian to Chinese firms; (b) Hussain (1998) who identified, "cultural prerequisites," e.g. in overcoming "cultural barriers" for TT in Brunei–Japan JVs; and (c) Iles and Yolles (2002) who highlighted the role of human resource management, specially in relation to knowledge migration and organisational learning – substantiating the H, I, and O dimensions in the THIO technology profiles in

Figure 7 conceptualises the need for closer integration along each of the H, I and O dimensions in order to achieve meaningful TKE. It highlights (on top) the need for relational integration along the H dimension and incorporates the need for structural integration along the O dimension. ICT–aided collaborative systems (in the I dimension) will further facilitate both relational and structural integration (and collaboration as in Figure 2). ICT is useful in empowering integration, both within and across organisations in a project (Ugwu et al., 2003a), and even across the industry (Kumaraswamy et al., 2004c).

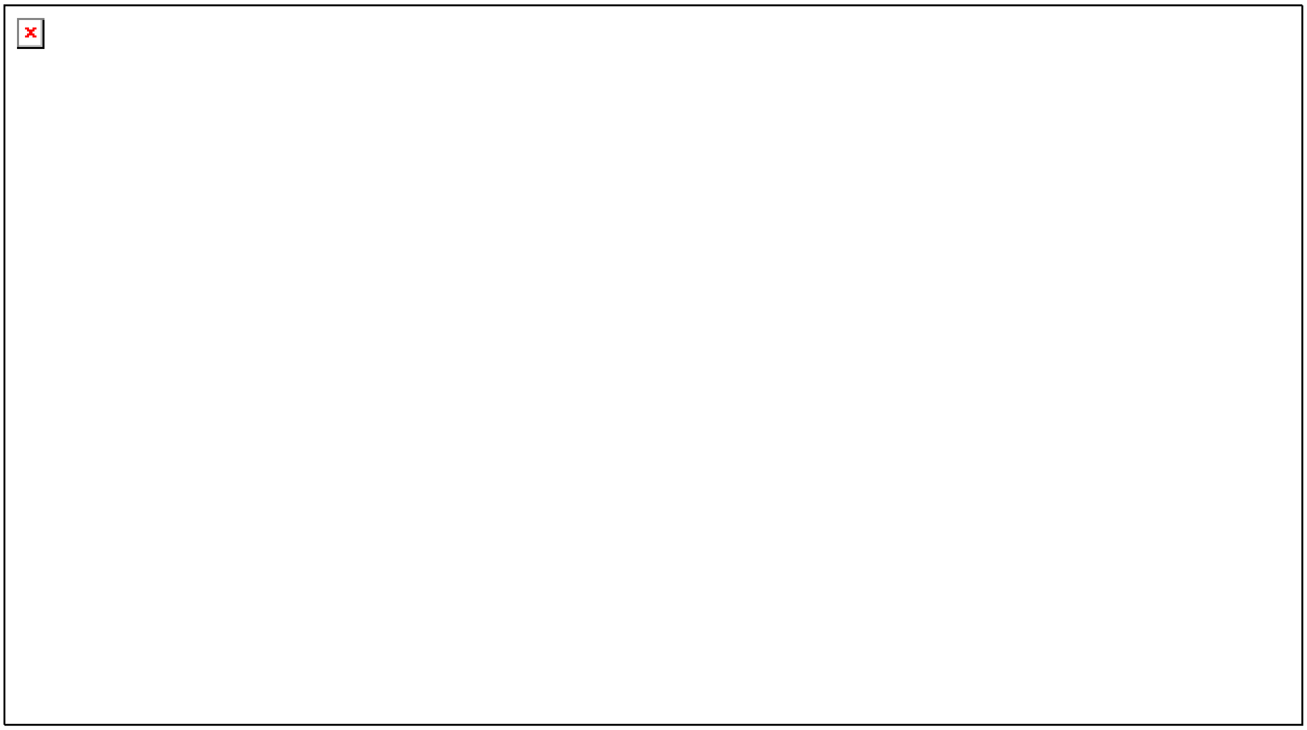

Figure 7. Facilitating TKE in JVs

Kumaraswamy et. al. (2004d) expanded on how (a) relational integration and (b) ICT-aided collaborative systems would complement (c) any structural integration at organisational level, as indicated above. All three may be hypothesised as interdependent prerequisites to ensuring effective transfers of T. A comprehensive evaluation model is planned in a more detailed study, for assessing the mutual transfers of such soft and hard factors, in the envisaged TKE. A broader framework for assessing international TTs has also been proposed (van Egmond and Kumaraswamy, 2002; van Egmond et al., 2003).

CONCLUDING OBSERVATIONS

The above three recent surveys in Hong Kong elicited perceptions of construction industry practitioners on sets of barriers, drivers and potential benefits relating to TT, "technology exchange" and TKE in general, in JVs and across construction supply chains. The need for relational integration to achieve effective TKE links back to previous sections that highlighted the increasing demands and approaches to effective relational contracting, JRM and culturally integrated teams. These together relate back to (a) the broad and basic "national-infrastructure-construction industry development" model developed in Figure 1; as well as to (b) the MSS model for longer-term development of construction organisations. The shorter- term benefits from selecting more appropriate procurement and delivery systems are expected to be complemented by the longer-term development through organisational

...chnological systems. This cycle is completed by referring back to the ... the organisational learning-knowledge and technological systems.

"Caveats" are needed, both in TKE and as previously indicated in RC, since an unscrupulous partner may abuse the trust of another, and attempt to merely "get" (extract one-way) benefits, without "giving in return" (e.g., by only pretending to transfer benefits/add value). In this context, it is worth (a) recalling the previously discussed potential mutual benefits of RC, PPPs and other innovative approaches in developing construction project teams (and organisations in the long term); and (b) cautioning on the need for carefully controlled applications and development in these areas as well. This is critical, in order to avoid misuse or even misinterpretations of the possibilities, contributory roles and actual applications, that can easily lead to disillusion and failures.

The various models depicted in this paper range from basic broad-brush macro models as in Figure 1, to the more detailed JV model shown in Figure 7. Much remains to be done in fleshing out the frameworks, developing the knowledge-based, and operationalising and testing the models described in this paper, such as for developing and sustaining relationally integrated teams, more efficient supply chains and more effective PPPs. Ideally, some countries/construction industries and large organisations may adapt and test them in their own domains. Each domain will have its own needs, priorities, special background, conditions and constraints. Specific R&D agendas may thus be developed accordingly. Action plans may also be formulated at regional or national level, even starting with a sectoral focus, such as on the roadworks subsector in the case study from Sri Lanka, cited earlier in this paper. Comparisons of agendas and lessons learned may be arranged at a higher level, e.g. by an umbrella group such as CIB W107, injecting synergies and thereby accelerating the benefits from such exercises and the refinement of action plans to address the identified issues in each case.

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