ADDRESSING ISSUES ACROSS ORGANISATIONAL BOUNDARIES IN CONSTRUCTION PROJECTS

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ABSTRACT

The extensive and increasing specialisation in all sectors of the construction industry has prompted much criticism due to the common absence of sufficient coordination and collaboration of the separate organisations culminating in accusations that such fragmentation leads to poor performance.This paper focuses on the managerial issues which emerge due to the diversity of individual organisations which must be assembled to execute engineering construction projects. Managing any organisational interface is notoriously problematic and has prompted the generation oftheories concerning management of boundaries – including boundary spanning and boundary objects. This paper examines the theory, research perspectives and findings to date and relates them to the management of engineering construction projects. It is concluded that recognition of performance interdependence amongst project participants is an essential underpinning of cooperationand development and use of appropriate boundary management through boundary spanning and boundary objects can foster interaction and coordination even with participants' retention of their individual goals.

KEYWORDS
Boundary Management, Boundary Objects, Boundary Spanning, Complexity,Engineering Construction Projects, Fragmentation, Innovation, Interdependence.

Introduction: Background and Context

Fragmentation is a 'dirty word' in the construction sectors. It has been employed extensively in reports as a causal explanation of many of the ills of the industry, most of which relate to, allegedly, poor performance (Latham,1994; Egan, 1998;Construction Industry Review Committee, 2001). Fragmentation is defined as 'A breaking or separation into fragments' where a fragment is 'a (comparatively) small detached portion of anything; A detached, isolated, or incomplete part; a (comparatively) small portion of anything' (OED, 2010). Such use of 'fragmentation' intentionally carries negative connotations; however, that is not necessarily the reality. By changing the word but maintaining the extant industrial structure, terms such as 'differentiated' or 'specialist' could be employed; indeed, Adam Smith (Smith, 1789/1970) was an arch proponent of fragmentation in advocating division of labour to enhance productivity, as pursued in 'scientific management'– a path which construction, and most other sectors, have adopted with great enthusiasm.

Structurally-based concerns regarding fragmentation are addressed by Lawrence and Lorsch (1967) in their treatise on differentiation and integration. Given that technologies are increasingly complicated and that effectiveness and efficiency considerations prompt commensurate specialisation / division of labour / differentiation, then the organisational / managerial imperative shifts to integration for the supply of goods and services to ultimate consumers. Hence, acknowledging and respecting the differentiation and the consequent independence of 'component' suppliers lie at the core of integrating those suppliers' contributions and securing their commitment to deliver the final output. Thus, the fragmentation criticism is not one relating to industrial structure primarily, but concernshow integration operates in the market-social context to provide goods and services to customers – organisational and individual behaviour being the core focus.

Specialisation has caused differentiation and led to increasingly complex project organisational structures involving numerous specialist firms with each having its own boundary to delineate functional and/or economic activities. Hence, performance of the project organisations, temporary multi-organisations (TMOs), is dictated to a large extent by how well the boundary activities are planned and managed, and how permeable the boundaries are to allow information flow and knowledge sharing.

This paperexamines (1) behavioural issues (in the social-technical system) which affect the relationships of team boundary spanning activities and team/organisation performance;and (2) boundary management from the perspectives of complex organisations – implications for complex engineering construction projects (such as projects executed through public private partnerships (PPPs) and other forms of joint ventures (JVs)). In investigating those issues, the paper adopts a general perspective of construction projects and then focuses on the particulars of major engineering construction projects.

Fragmentation and the concept of team boundary

Essentially, the life cycles of the great majority of construction projects are replete with boundaries which have to be managed. It is not only the realisation phase of such projects which incurs TMOs (the 'quasi-firm', Eccles, 1981) but also the occupation and use and, even, the disposal phases. Further, the temporal nature of fragmentation (transient involvements of participants in project TMOs and different participants on successive projects) constrains the acquisition and passing-on of knowledge between projects and its capturing by permanent organisations. The occupation and use phase (by far the most protracted for the majority of projects) is, now, widely subject to outsourcing of 'facility management' activities, usually including transient involvement of specialist subcontractors for the work required (both construction and building operating related – e.g., security). Thus, construction projects are executed by varying combinations of permanent and temporary organisations, both categories of which exhibit performance which is consequent on the other and, for the constituents of the temporary organisations, is interdependent on the other members of the TMO (see, e.g., Berggren, Söderlund and Anderson, 2001).

The current issues are captured by Owen and eight further authors (2010) who note that 'The increased performance requirements and complexity of constructed facilities require additional specialists and increase the need for integration skills.'Thus, this section explores the natures of boundaries of organisations likely to be involved with construction projects, examines managerial issues relating to the boundaries, and discusses the consequences of alternative boundary management approaches.

Fragmentation

Neo-classical economics is rooted in selfishness of human behaviour. The general behavioural assumption is of ultimate self-interest (e.g., Dawkins, 2006) under which individuals behave to maximise their own satisfaction and firms behave to maximise their own profits (although the severence of ownership and management and the recognised importance of growth of the firm has modified the single objective assumption – Baumol, 1959). Even in highly developed Western capitalist market economies, grounded in very individualistic societies (see Hofstede, 2001), there is increasing evidence that such assumed behaviour by individuals and firms is not universal (e.g., Etzioni, 1988).However, despite the evolution of apparently altruistic behaviour, including citizenship behaviour, corporate social responsibility (CSR) / performance (CSP), and greening/sustainability, a strong core of adherence to self-interest remains (Coase, 1937; Friedman, 1970; Williamson, 1985).

Generally, fragmentation has been regarded as occurring along two dimensions – horizontal and vertical. Horizontal fragmentation concerns the multiplicity of actors (individuals, organisations, business units) which carry out functions at, approximately, the same stage of a process (e.g., schematic design of a building). Vertical fragmentation concerns the splitting up of a total process into components / stages which are executed by significantly separated functional actors (e.g., structural engineering design and reinforcement supply and fix). Reports on the construction industry have variously, but consistently, criticised the industry for its fragmentation – Egan (1998) regarding horizontal aspects (at the 'main' contractor level); Higgin and Jessop (1965) regarding vertical fragmentation (that in no other industry is production so far removed from design). The construction industry exhibits extensive fragmentation along both dimensions; especially for major projects, there is increasingly likely to be extensive fragmentation of the client/customer also – owners, financiers, occupiers, users – plus government agencies and a variety of other stakeholders.

Horizontal fragmentation is common in most industries – the variety of organisations differ by type of business unit (but, usually, companies – especially, public limited companies – dominate), structure, size, location, and scope.The Banwell Report (1964) was instrumental in clients of the industry (particularly, public sector) moving from open to selective tendering for constructor selection in endeavouring to secure bidders more suited to the work involved in a project and, hence, both improved performance of project realisations and reduced costs of tendering through less unproductive bidding. Latterly, additional procedures have been incorporated in bidding (notably *curricula vitae* of persons whom the tenderer will use to manage the project construction) and consultant or in-house project managers are employed to oversee project realisation as the client's main agent.

A systems theory perspective is illuminating. The 'hard' systems model (Cleland and King, 1983) comprises inputs, transformation/conversion, and outputs with feedback / feedforward loops to facilitate control. An essential, but often overlooked, concern is the boundary of the system – its location (to denote the system's content and activities, etc.), its flexibility (to change the scope / scale), its permeability (concerning ease of movement across the boundary), and its effects (changes consequent upon movement across the boundary) (see also: Martin, *et al*., 2004). 'Soft' systems adapt the model to address the human aspects of a system and its operation (see, e.g., Green and Simister, 1999 for a discussion regarding construction). The presence of boundaries implies differences and differences imply issues of trust (Lewicki, McAllister and Bies, 1998).

Drach-Zahavy and Somech (2010) confirm that boundaries are established to separate teams (in-groups) from others such that in-group activities (and management) may be facilitated by some degree of independence (isolation). However, '…because teams cannot internally generate all needed resources, they must engage in boundary activity to protect themselves as well as to acquire resources critical for their survival…'(*ibid*).Thus, they posit four boundary activities: buffering – separating the in-group and preserving its resources; bringing-up borders (boundaries) – melding members into a coherent team; scouting – scanning and securing resources from the environment; coordinating – relating to out-groups in the environment with which the in-group is interdependent for success. That demonstrates a 'competing forces model' of independence (differentiation/specialisation) and interdependence (integration/cooperation/coordination) in which the forces strive for equilibrium in dynamic environments (akin to Lawrence and Lorsch, 1967).

In various guises, a great deal of attention is devoted to overcoming boundaries between (sub-)systems, including joint ventures and other forms of alliance between organisations (Sheth and Parvatiyar, 1992), bridging and bonding in the context of social capital (Edelman, Bresnen, Newell, Scarborough and Swan, 2004), supply chains and (social) networks (Cox, 1999), and boundary objects (Bresnen, 2010). Recent perspectives afforded by chaos theory (Stewart, 2002) and by complexity theory (Anderson, 1999; Lucas, 2005) add to understanding relationships and consequences within systems while other developments, including prospect theory (Kahneman and Tversky, 1979), facilitate appreciation of what is being sought, behaviour, and how evaluations operate.

Organisational Boundaries – inter-team and intra-team

The location of any organisational boundary lies at the limits of the organisation – as defined legally, by its formal systems, or/and informally by its informal/social systems, etc.; however, moving from formal delineation to more informal delineation leads to fuzziness in determination of where the limits of the organisation lie, e.g., whether or not formal alliances, joint ventures, etc. are employed (i.e., buffering). Clearly, the organisation's legal boundary is extended if the firm takes over another; it is also extended by entering a formal alliance or joint venture, although differences do arise between equity and non-equity joint ventures (Glaister, Husan and Buckley, 1998). However, if a construction firm undertakes a project via one of the common procurement routes, the location of the formal (legal) organisational boundary remains unchanged but the informal boundary is extended to encompass the project – at least, that organisation's role on the project.

A consequence of TMOs is that a multi-tier system of boundaries results – the formal organisation's boundaries; the boundaries around each organisation's activity groups operating on the project; the boundaries around each within-an-organisation group on the project; and the boundaries around informal groups which form across members of different participating organisations. The resultant lack of clarity of organisational boundary locations generates potential area of possible conflict (domain/jurisdiction and role conflicts). Otherwise, such 'fragile' arrangements are considered as areas of 'coopetition' (Nalebuff and Brandenburger, 1996), collaborative competition (Kaler, 2009), or competitive collaboration – participants must collaborate to realise the project but do so (somewhat) competitively with each other in pursuit of their own goals in a zero-sum game.

Boundary effects concern changes which are dependent and consequent upon merely crossing a boundary. For instance, incompatibility of organisational cultures/climates is likely to generate conflict due to (innocent) inappropriate behaviour, etc. – especially if the persons involved are unaware of / insensitive to such differences (see, e.g., Fellows and Liu, 2008).

The extending complications of projects promote increasing specialisation, and interdependencies of those specialisations in combining to yield the complete project. Commonly, that situation is treated in a reductionist way by splitting the project into manageable components (e.g. procurement system composed of people, processes, function mechanisms differentiated into project phases dominated by different teams of consultant and/or specialist contractors etc.) which are analysed individually and the results combined additively (e.g.,

Reugg and Marshall, 1990; Lawrence and Scanlan, 2007). Thus, holistic/synergistic impacts of component combinations are omitted (Lucas, 2005).

Thompson (1967) determines three forms of interdependencies relating to tasks (or arrangement of work flows). In sequential interdependency, tasks must be carried out in strict order (series); in reciprocal interdependency, outputs of one task are inputs for one or more other tasks, which may cycle iteratively (as in architectural and structural engineering design); in pooled interdependency, each task provides (only) a contribution to the whole and may do so independently (which facilitates parallel working). Thompson (1967) raised two primary questions concerning task interdependencies: what causes task interdependency and who are task interdependent – the answers are contingent in that they are determined by technology and by how the work is organised. Van de Ven, Delbecq and Koenig (1967) extended the debate by adding team interdependencies which may be analysed from both inter- and intra-team (in-group) perspectives.Thus, interdependency may be regarded as a multi-layered phenomenon comprising tasks at intra-and inter-group (team) levels.

In more recent studies, inter-team task interdependence refers to the extent to which a team believes it is dependent on other teams in the organisation to carry out its tasks and perform effectively (Hulsheger, Anderson and Salgado, 2009).The emerging research on inter-team networking typically emphasises the beneficial role of creating linkages with other teams (Oh, Labianca and Chung, 2006).In any case, boundary activities should refer to all the interdependent activities that teams engage in to manage their boundaries (Yan and Louis, 1999; Drach-Zahavy and Somech, 2010).

The emergence of team-based project organisations may require shifting the focus from intra-team to inter-team activities in order to understand organisational functioning. According to Drach-Zahavy and Somech (2010), inter-team boundary activity is contingent on inter-team goal and task interdependence, while team heterogeneity, inter-team power relations, organisational culture (individualism-collectivism), and favourable external environment are important moderators of the relationships between inter-team interdependence configuration, boundary activity, team performance and organisational performance. Asocial identity perspective (Ashforth and Mael, 1989; Hogg, 2000) and interactionism (Mischel, 1977) provide the basis for Drach-Zahavy and Somech's (2010:146-148) model in which (1) boundary activities are defined as "team processes necessary to carry out the task at hand that are directed toward external agents in a team's focal environment to gain resources and promote and protect itself" (see also Ancona and Caldwell, 1992, Yan and Louis, 1999); (2) external activities are referred to as "interactions aimed outside the team boundary" and internal activities are defined as "intra-team processes occurring within the team boundary, such as forming and enforcing team norms, communication among members, use of internal resources and creation of a shared team vision" (see also Ancona and Caldwell, 1992; Choi, 2002); and (3) external team networking is defined as "those interactions aimed outside the team boundary and directly related to team performance" (Joshi, 2006).

Importantly, Drach-Zahavy and Somech (2010) conclude that boundary activity determines whether higher team performance can fully translate into higher organisational performance (in terms of team functioning in the context of interdependent relations with other organisational teams). [In the context of construction projects, organisational teams are taken to mean various specialist teams in the project organisation, such as design team, contracting team etc.]

Boundary Spanning and Boundary Objects

In the face of global competition, changing economic conditions and increased project (tasks) complexity, there is a greater need for project (organisational) teams to coordinate interdependent work efforts and bridge disconnected teams by managing relationships external to themselves. The team's efforts to establish and manage external linkages (team boundary spanning) can occur within an organisation and/or across organisational boundaries. Team boundary spanning behaviours have been shown to be critical drivers to performance and organisational innovation (e.g. Hargadon, 1998). Through team boundary spanning behaviours, teams bridge diverse and disconnected parties and act as critical channels for information transfer and innovation (e.g., Hargadon, 1998) – which provides basis for knowledge sharing research and social network research.

Marrone (2010:914) defines (1) team boundary spanning as "the team's actions to establish linkages and manage interactions with parties in the external environment"; (2) external environment as "the team's embedding environment (that which resides outside of the team's own boundary) and may include actors or other teams residing within or outside of the boundary spanning team's host organisation"; and (3) team boundary spanning activities as "external team processes, which reflects the nature of the team's interactions with parties external to the team itself, and therefore, they differ in a meaningful way from internal team

processes, which are intra-team and involve the nature of team member interactions with one another to internally develop strategies, coordinate workloads, and manage interpersonal conflict" (see also Marks, de Church, Mathieu, Panzer and Alonso, 2005).

Boundary spanning, acting across one or more boundaries, is undertaken by persons appointed specifically to do so (designated boundary spanners) as well as by many others doing so informally; often, boundary spanning is analysed and depicted using social network analysis (Di Marco, Taylor and Alin, 2010). Boundary spanning occurs extensively between sub-units within a single organisation as well as between separate organisations in dyadic and more extensive relationship patterns. Boundary spanning includes making representations to stakeholders, coordination with other (out-) groups and seeking information from external bodies (Ancona and Caldwell, 1992); such activities are important for performance (Gladstein, 1984) and for innovation (Hargadon, 1998).

Boundary spanning involves bridging – finding and connecting with external organisations which the boundary spanner perceives as being of value – and, then, bonding to build relationships with those external organisations but also to foster internal relationships within the organisation. Thus, boundary spanning acts to extend and enhance the social capital of the organisation and, thereby, foster reciprocity and trust, and extend the informal boundary of the organisation (in-group). However, social capital may also comprise norms of conformity and compliance and, further, may engender stronger boundaries around the in-group which, in consequence, limits external communication and so, is detrimental to creativity and innovation through the reduction of (novel) stimuli (see, e.g., Edelman *et al.*, 2004).

Boundary spanning between different communities of knowledge and of practice involves issues of comprehension and translation between the communities to ensure clarity of meaning (and purpose); such issues are exacerbated internationally with overlays of different languages and cultures. Traditionally, in construction, a primary boundary spanning role is allocated to the architect on building construction and the engineer on engineering construction projects; the particular role (discipline / profession) of project manager is emerging for overall management of projects – notably, the boundary spanning requirements.

Boundary spanning-in-practice (those who perform boundary spanning – who may, or may not have been so designated) requires that the person(s) become legitimate (hence, accepted) in the groups concerned; that may mean that they are fairly peripheral for the specialist activities in each group but their ability to negotiate relationships between the communities of practice involved is the essence of their role (Levina and Vaast, 2005). Thus, the 'primary task' of boundary spanning is enabling and enhancing flows across boundaries between communities of (differing) knowledge/practice (and interests) – thereby increasing the permeability of those boundaries and reducing boundary effects.

Based on Marrone (2010), there are two important points to note: (1) team boundary spanning behaviour of a single team is a team-level construct, one that originates from individual behaviours of team members – hence, the individual behavioural contributions to boundary spanning may vary depending on task and team interdependencies (because individual contributions may not be isomorphic or converging); (2) team boundary spanning is not confined to the team level, and can be represented as the relational ties established between various actors from a social network perspective – whereby actors are equivalent to single teams and/or other social entities. "Consequently, attributes and behaviours of an individual actor (e.g. a focal team's boundary spanning) and the structured pattern of relationships it is embedded within (i.e., the network characteristics and behaviour) are relevant (Wasserman and Faust, 1994)" (Marrone, 2010: 915). Thus, Marrone (2010) proposes network boundary spanning to depict boundary spanning actions occurring not only within a system of mutually interdependent teams but also within a set of diverse actors with varying degrees of interdependence. [In the context of construction, that concept is particularly useful for complex PPP or JVprojects.]

It is not only individuals who are involved with boundary spanning but so are various 'objects' – which constitute the tools of boundary spanning. Star and Griesemer (1989) developed the formal notion of boundary objects. Oswick and Robertson (2009) note that boundary objects have both performative roles (indicating what is required - drawing, when - programme, at what quality - specification, and for what price - quotation / priced bill of quantities) and mediating roles (communicating and discursive aspects to aid determination of the final, hopefully jointly developed and agreed, object).

Carlile (2002) proposes a typology of boundary objects according to a typology of boundaries of knowledge: repositories (syntactic boundaries requiring common language for communication), standardised forms and methods (semantic boundaries requiring understanding of meaning), and objects, models and maps (pragmatic

boundaries necessitating accommodation of diverse goals and interests). However, if knowledge in one field must be translated into a common language for transmission to and comprehension in another field, in which the knowledge (information) may be translated again, there is a significant possibility of information degradation or loss (Grant, 1996), hence the necessity to ensure the appropriate level of express content of the common language – a particular concern for societies which use high context languages.

Thus, Carlile (2002) asserts the three characteristics of effective boundary objects to be'a shared syntax or language for individuals to represent their knowledge'; 'a concrete means for individuals to specify and learn about their differences and dependencies…'and 'facilitates a process where individuals can jointly transform their knowledge.' The first two facets constitute practical aspects while the third is political. The political facet is important as boundary objects impact on social relations, including status (Bechky, 2003).

Particular features of boundary objects are that they are susceptible to differing interpretations (plastic) such that they can be understood and used for individual needs – and, thereby, promote interaction, debate and inquiry by diverse communities of practice. Often, those communities of practice access and use boundary objects interdependently on projects and so, those objects must be sufficiently robust to maintain their identity (recognisable structure and data / information content despite different comprehension and use contexts– see, Lawrence and Scanlan (2007) for a discussion of programming techniques and autoCAD on engineering projects including their role as boundary objects).

In many (project) instances there is a multiplicity of boundary objects-in-use which, commonly, associate to form 'boundary infrastructures' (networks of boundary objects) (Bowker and Star, 1999). The necessary flows of information on construction projects to select participants and to convey information in a multiplicity of forms – for project planning, feasibility, and realisation as well as maintenance, upgrading, and adaptation during occupation and use, and for final disposal – demonstrate that boundary infrastructures will occur. A common occurrence is for omissions, discrepancies and divergencies to occur between boundary objects' contents which, for efficient and effective progress, require early detection and resolution. Early detection should be promoted through use of CAD and BIM systems amongst designers, constructors and project users, provided the system is shared and access is adequate (see Lawrence and Scanlan, 2007). Checking of design completeness and coherence by 'traditional' means ('overlay drafting' of drawings, quantity surveyors' query sheets at preparation of bills of quantities, etc.) are not foolproof, as the incidence of post contract variations bears witness; further, the terms in many standard form contracts concerning contractors' discovery of discrepancies and divergences are barely adequate to address other aspects of such difficulties.

Boundary Management

Modern construction increasingly encompasses complex projects with multi-stakeholders. As such, the organisations involved in construction procurement are often complex organisations capable of exhibiting non-linear behaviours. Complex adaptive systems theories presume that the adaptation of a system emerges from the efforts of individual agents that attempt to improve their own payoffs, but the individuals' payoffs depend on the choices that other agents make– often the case on complex projects involving multi-stakeholders. Hence, agents coevolve with one another where local adaptations lead to the formation of continually evolving niches (Anderson, 1999) which means that the complex systems do not operate at equilibrium of globally optimal system performance– i.e., value conflicts are resolved as compromises amongst multi-stakeholders on complex projects. However, Morel and Ramanujam (1999) argue that such apparent disequilibrium is actually a dynamic equilibrium. Following this line of argument, boundary spanning is incidental (to the system equilibrium) as the agents (and other resources) shift/manoeuvre activities and behaviours to maintain the equilibrium with other coevolving systems (balancing the needs/goals of multi-stakeholders both within and external to the project TMO).Brown and Eisenhardt (1998) and Weick (1979) argue thatorganisations can continue to exist only if they maintain a balance between flexibility and stability. Additionally, they contend that the strategic equilibrium over time for an organisation is a combination of frequent small changes made in an improvisational way that occasionally cumulate into radical strategic innovations, changing the terms of competition fundamentally.

Simon (1996) points out that any adaptive entity contains an adaptive inner environment and any complex adaptive systems are nested hierarchies that contain other complex adaptive systems. More importantly, every aspect of the complex adaptive system (agents, their schemata, the nature and strength of connections between them and their fitness functions) can change over time, i.e. new systems may appear, old systems may become extinct and existing ones may survive in a fundamentally new form. Hence, a complex engineering project is an adaptive entity containing an adaptive inner project environment with its own nested hierarchies of complex systems of participant organisations and an external project environment with complex stakeholder network

systems. It is at the boundaries of the systems where management of agents, objects and spanning activities occur to maintain the adaptiveness and flexibility of the systems to achieve dynamic equilibrium– the desired project outcome for complex engineering construction project procurement.

Boundary management is, therefore, very important for challenging complex engineering project delivery where networks of firms deal with a myriad of task, specialisation, resource, and other boundaries in the execution of complex (and, often, interdependent) projects.In many organisations, there are both intra- and inter-organisational boundaries and, although intra-organisational boundaries may be mitigated by over-arching common objectives etc. relating to the whole organisation, they are, nonetheless, important (such as differences between on-site engineers and office-based engineers – Rooke, Seymour and Fellows, 2003). The structuring of interactions and, hence, the configurations of boundaries / interfaces is complicated but such complications are mitigated by commitment to common goals – as an essential for teamwork.One important task of (project) management is to determine the commonalities of goals/objectives and ensure that they are articulated, agreed and accepted, with a view to securing higher levels of commitment and, consequently, performance (see, Nicolini, 2002; Dainty,Bryman, Price, Greasley, Soetanto and King, 2005).

Boundaries may be physical (such as site hoardings) and non-physical (notably, between disciplines / communities of practice). In any instance, the boundary (purposely) serves to separate, often with an objective of protecting what is inside the boundary by excluding what lies outside and controlling movements across the boundary. Management may be regarded as making and implementing goal-directed decisions concerning people, which confirms the drivers as the operative goals, people as both the generators of goals and the active means of their realisation, the future orientation of decisions, and the requirement for them to be carried out – to complete the loop, via performance, towards goal realisation.

Boundary management may be regarded as safeguarding self and own interests while endeavouring to overcome the boundary in order to gain from others. In the context of international joint ventures (IJVs) those who manage across boundaries, 'boundary spanners', '…are "judges" of procedural fairness, "gatekeepers" of inflows…and "representatives" of outflows…' (Luo, 2009).

Discussion

Levinia and Vaast (2005) articulate the functional relationship between boundary spanners-in-practice and boundary objects-in-use. Boundary spanners-in-practice:

(a) 'reflect on objects from each field and reflect on their utility within the context of the new joint field'
(b) 'create new artifacts (or adopt existing ones) and attempt to establish their new identity within the new joint field'
(c) 'use various species of capital to establish the local usefulness and symbolic value of the artifacts they are promoting as boundary objects'
(d) 'use emerging boundary objects-in-practice 'to signify their position in the new joint field and the position of their field vis-à-vis others'.

There is a small amount of emerging evidence that use of procurement routes which foster integration of designers, and of designers with constructors, leads to projects with improved project management performance (time and cost) (Vasters, Prins and Koppels, 2010; Constructing Excellence, 2007). [Note thatVasters*et al*. findings are tentative and that in respect of 'demonstrator projects' the outcomes may be somewhat questionable due to the likelihood of elements of 'self fulfilling prophesies' being present.]

Construction projects are highly labour intensive; as such, the organisations which carry out those projects are appropriately regarded as social collectivities which draw on individual and social expertise (knowledge and skills) to yield goods and services (see, Kogut and Zander, 1992). Given the multiplicity of expertise required for engineering construction projects and the diversity of organisations within which the expertise resides, there are differences in professional values and allegiances which are difficult to integrate. Thus, boundary spanners, and the boundary objects which they assist to generate and use, are vital for communication and coordination. Higher order considerations, notably, trust and commitment, operate to foster development of a common language and processes amongst participants, all of which are enhanced through long-term relationships, adhering to the theory of familiarity (Aldrich, 1971; Das and Teng, 1998). Unfortunately, such developments are severely restricted through the lack of continuity of employment of organisations and personnel over series of projects – an important consideration for programme management over series of projects.

In construction projects, a diversity of boundary objects are used at multiple stages and for multiple purposes (briefing documents, value management reports, contracts, drawings, specifications, product guarantees, etc.). The separation (fragmentation) of the various disciplines and organisations which use such objects is extensive and widely documented (see, above) and the interpretive flexibility gives rise to conflicts, disputes and claims.

In realisations of construction projects, CAD programs are becoming increasingly extended in scope and, through 3-D and 4-D versions, as in BIM.Such boundary objects are also used to help maintenance provisions and processes. Thus, those boundary objects demonstrate success as common information spaces used by project participants who, thereby, interact and coordinate their activities whilst maintaining their own goals (see Bartel and Garud, 2003).

Even within the overlay of partnering procurement to encourage cooperation between parties on construction projects (see Bresnen and Marshall 2000a; 2000b; Bresnen 2010), boundaries remain clear between organisations due to differing interests and perspectives. That suggests insufficient awareness of mutual interdependencies to motivate collaboration, despite the formal contracts and the particular partnering processes adopted (n.b., partnering workshops and the production of partnering charters). Thus, the differences are highly ingrained andBresnen (2010) demonstrates '…the difficulty of using designated boundary objects as mechanisms to achieve integration where practice is highly decentralised, diffused and distributed (Sapsed and Salter, 2004)'.

Attention to partnering and other relational considerations (e.g., relational contracting, including attention to covenantal relationships) lie along a purposive spectrum of rationale from impacting on performance to impacting on the social relationships (primarily, in the project workplace). The perspective adopted seemingly reflects (degrees of) positivism/functionalism and interpretivism/social constructivism epistemologies, in alignment with being and becoming ontologies (discussed by Winter, Smith, Morris and Cicmil, 2006 regarding projects). Whether the goal of improving relationships is to effect improvements in project (realisation) performance or to improve relationships as a social 'good', it still places onus on boundary management, especially boundary spanners'activities themselves and with boundary objects, to foster commitment, collaboration, attachment, and harmony and to prevent negative conflict, etc. Hence, projects are seen as media in which boundary management can secure greater meaning, sense of worth and achievement (self actualisation– Maslow, 1954).

In respect of automotive engineering (a sector with whichconstruction is popularly compared), Takeishi (2001) determines that '…outsourcing does not work effectively without extensive internal effort.' Given that outsourcing is extensive for facility management of real estate, subcontracting is extremely extensive in construction, and engagement of consultants and other specialists is usual in design of projects, it may be postulated that the success of such practices is dependent not only on the expertise of those engaged but also on the abilities of the principal (usually, via the project manager) to communicate with them and to properly incorporate their proffered inputs (commonly as boundary objects).

Team boundary management is a significant contributor to team performance outcomes, including team innovation, efficiency and goal achievement (Marrone, 2010). These benefits appear to exist across team types, such as development teams, production/service teams and action teams.

There are several aspects regarding boundaries and their managementon engineering construction projectswhich generate important questions for research:

1. If firms are a repositories of capabilities, as determined by the social knowledge embedded in enduring individual relationships structured by organising principles, how are the team boundaries defined and how can teams span boundaries most effectively (both within and between project TMOs and the associated permanent organisations)?
2. How do teams and members allocate resources across boundary activities and do teams that focus externally achieve higher performance than teams that focus internally?
3. How do internal network structures assist/hinder the impact of team boundary spanning activities and internal team functioning and performance?
4. How does external interdependence (across teams) affect the boundary spanning-performance relationship?

Conclusions

Construction is a fragmented industry – horizontally, vertically, and temporally. Horizontal fragmentation is addressed through work allocation mechanisms; the most common of which remains as single stage competitive bidding with the consequent issues relating to opportunistic behaviour which have become deeply ingrained. Those consequences of horizontal fragmentation are exacerbated, if not dominated, by the effects of vertical fragmentation. Vertical fragmentation involves more extensive differences and, particularly through the operation of 'traditional' procurement, reinforces the zero-sum game of price competitive work allocation. Temporal fragmentation is extensive – as evidenced by the transient membership of project TMOs by both many organisations and the agents who represent member organisations. Alternative procurement approaches, devised to overcome such problems (notably 'partnering') have, so far, enjoyed limited 'success' as organisational boundaries remain strong, and boundary spanning management is (consequentially) constrained and limited in effects.Boundaries commonly denote demarcations of cultures, climates, knowledge, practices, and resourceswhich necessitate behavioural modifications for effective spanning and securing effective and coordinated contributions to projects through engendering adequate trust.

A primary concern of boundary spanning is to nurture cooperation, collaboration and commitment through sensitivity to the diverse natures and interests of the participants and so, to foster identification, communication, acceptance and pursuit of common goals. That occurs as boundary objects are representations of portions of knowledge drawn from one or more communities of practice (in-groups with stocks of particular knowledge and practice); thus, the role of boundary spanners concerns securing useful boundary objects and facilitating easily intelligible and usable flows across the boundaries.

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