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A contingency perspective on the strategic management of construction projects: producers, production, planning and project environments

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The variety in built environment projects requires the adoption of a strategic perspective that recognizes the unique characteristics of and the multiple managerial facets of a construction project. This paper proposes a conceptual model that identifies and organizes three strategic decision areas: Producers, Production and Planning and a contingency construct Project Environment. The result is a set of theoretical propositions and a strategic framework that argues that performance will be enhanced by the fit between the project environment and the strategic decisions that are made. This model is suggested to serve as a catalyst to articulate theory and conduct research.

Keywords: Construction management, construction planning, contingency theory, contracts, learning.

Introduction

Project management in general and the management of Architectural, Engineering and Construction (AEC) projects in particular is experiencing a shift in the focus of research. Scholars are moving beyond a deductive model and are actively developing theories (Koskela, 2008; Levitt, 2012) of construction management that allow an increased understanding of the complex phenomena that occur during the process of realizing the built environment. This focus is at least partially driven by recognition that success is not solely defined by the accomplishment of tasks in an efficient manner, but rather by the ability to create an environment that facilitates the achievement of diverse stakeholder goals.

AEC projects are unique in that they are almost always defined as temporary organizations. Multiple firms, broadly defined as owners, designers and constructors, form an organization defined by temporal contracts. The designers and constructors assume the responsibility and risk associated with the completion of discrete parts of a project in return for compensation. The compensation is paid by the owner in anticipation of future benefits resulting from the project. This paper focuses on the commercial construction industry which spans a range of products as diverse as strip malls, apartment/office complexes, infrastructure and petrochemical plants. While there will be major differences in the environments in which these projects are executed they will all involve the management of producers, production and planning.

Three streams of scholarship have served as the basis for informing much of the current search for a theory of the management of AEC projects: lean production (Koskela *et al.*, 2002), the 'economics/information approach' (Winch, 2002) and the prescriptive approach of Project Management Body of Knowledge (PMBOK) (Project Management Institute [PMI], 2008). While each stream acknowledges the contribution of the others, they have maintained rigid positions that have resisted efforts at synthesis (Koskela and Ballard, 2006; Winch, 2006). In addition, there are a number of additional reference disciplines that further our understanding of the process of realizing the built environment.

This paper begins to address this breadth by proposing a conceptual model that organizes multiple perspectives and serves as a strategic framework for managing AEC projects. The result is a model that suggests that there is more than one unified theory for the management of AEC projects. The 'need to develop theoretical perspectives combining multiple lenses has become pressing' as '… the complexity of management …

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requires explanations that are matched in complexity … ' (Okhuysen and Bonardi, 2011, p. 6).

The foundation of the model bears similarities to the Hanish and Wald (2012) project management research framework. It rests on three basic concepts. The first argues that a contingency perspective is necessary to organize and integrate these areas. No one project structure is right for all projects. The second argues that in addition to the traditional emphasis on the management of production, the inter-organizational nature of AEC projects requires that there be a focus on the management of the producers. The third proposes that the management of both the producers and production in a complex environment must extend beyond planning and control. The management process should facilitate learning (Puddicombe, 2006).

The resulting framework argues that performance will be enhanced by addressing three separate but potentially synergistic decision areas. The first area relates to the management of producers through the project's formal and informal organizational structures. These structures are defined by the contractual and the personal relationships between the firms and the individuals who represent them. Is the project organized as a zero-sum game or one that is defined by collaboration? The second area addresses the management of production and the philosophy used to manage ongoing operations. Is the deterministic project approach described by PMBOK or the adaptable process-based approach described by Lean Construction employed? The third area supports the first two decisions. Is management seen as an exercise in control defined by fiat or is it an exercise in learning facilitated by processes such as virtual design and construction (VDC)? These are strategic decisions, and the fit between the tangible characteristics of the project and these decisions should result in superior performance.

The balance of this paper focuses on organizing and synthesizing these various disciplines. The first part of the paper lays out a contingency approach to decision-making. It argues that complexity and novelty define fundamental project characteristics that determine the efficacy of various decisions. The second part examines the management of producers. It draws on work in organizational economics, traditional management theory (TMT) and social psychology. The third part of the paper explores the management of production. Strategic operations management theory informs our understanding of these activities. In the fourth section of the paper the importance of planning as learning is introduced. Finally, the basis for conceiving the project as the management of producers, production and planning is developed. A theoretical model integrating all these areas around the concepts of the project environment is proposed. This model is suggested to serve as a catalyst to articulate theory and conduct research. The competing research streams are seen as addressing distinct but interrelated issues and environments. Understanding the synergy between these ideas will help us advance the performance of the industry.

Contingency theory and construction project management

Strategy research has found a contingency approach to be extremely beneficial in the development and testing of theories and hypotheses. It has lent significant support to the fundamental precept that, ' … no universal set of strategic choices exists that is optimal for all businesses, irrespective of their resource positions and environmental context' (Ginsberg and Venkatraman, 1985, p. 421).

The wide acceptance of contingency theory suggests that the management of projects could also benefit from a contingency approach. Indeed there is increasing acceptance that the one-size-fits-all approach that is evident in much project-management research does not reflect the reality of modern projects (Shenhar, 2001; Hanish and Wald, 2012). In the project studies that have applied a contingency perspective it has been seen to offer significant insight. Shenhar (2001) reported on an exploratory study of a contingency approach to projects. He identified and tested a framework that focused on technological uncertainty and system complexity. While admittedly exploratory, his study offered evidence that there was a need to adopt approaches that address the characteristics of the specific project. Other research (Shenhar *et al.*, 2002) has further validated the linkage between project characteristics, managerial action and project success. Salomo *et al.* (2007) applied a formal contingency approach to a study of new product-development projects. They hypothesized that the degree of innovativeness moderates the relationship between project-management approaches such as planning and project formality, and project success. Shenhar *et al.* (2005) applied their Novelty, Complexity, Technology and Pace model to an analysis of NASA projects and argue that projects need to access the unique project characteristics and their impact on the project-management approach. Carroll and Burton (2012) argue that an information-processing approach (Galbraith, 1977) provides critical insight into the contingencies associated with the design of the project organization. Hanish and Wald (2012) proposed a generic project-management research framework that identified three contingency variables: complexity, dynamics and uncertainty.

Despite this emerging stream of project research, contingency theory has had little impact on construction-management research. While a few researchers (Slaughter, 1998; Puddicombe 2006, 2009) have implicitly adopted a contingency perspective most researchers have tended to follow 'the one-size-fits-all' approach. However, while a contingency perspective holds significant potential for informing construction project management the constructs of interest will differ from those of interest in most strategy research. In addition, the constructs of interest in AEC research may differ, at least in their operationalization, from the constructs in general project management.

Puddicombe (2011) building on work in R&D and new product development (Tatikonda and Rosenthal, 2000; Tidd and Bodley, 2002; Kim and Wilemon, 2003) operationalized and tested two contingency constructs important in understanding project performance: novelty and complexity. At a conceptual level, complexity is project focused and is viewed as a function of the number of parts and the resulting interactions between those parts. This approach builds on the work of Gidado (1996) and focuses on the technical complexity of the project. Novelty on the other hand requires reference to the actors' experience and refers to the degree of 'newness' associated with the project and each other. Previous research (Xia *et al.*, 2009) has suggested that project experience is a key factor in project outcomes. Here, we extend that to include experience between firms and individuals representing the firms. A critical distinction is that if a project is complex it is theoretically knowable. There may be a large number of parts and a high degree of interaction; however, if enough resources are applied to the project all eventualities can be identified and planned for. Novelty is different; it deals with project characteristics that may not have been previously encountered. There are main and interaction effects that therefore cannot be enumerated. These two constructs describe fundamental, tangible characteristics of all projects.

In Figure 1, high and low novelty and high and low technical complexity are two axes that define the internal project environment. The differences in these environments suggest the need for alternative strategies to achieve project success.

Figure 1 Project environments

In formal terms the four quadrants represent the possible states of nature for the project. They are defined as follows:

Understood: a known distribution of eventualities with a low standard deviation
Risky: a known (knowable) distribution of eventualities with a high standard deviation
Ambiguous: multiple possible distributions of eventualities with low standard deviations
Uncertain: multiple possible distributions of eventualities with high standard deviations and potentially fat tails

The variability in the payoff function that results from these different states of the project requires different strategic approaches in order to maximize performance (Pich *et al.*, 2002; Puddicombe, 2012). In the balance of the paper, the focus is on the project environments that occupy the margins: understood and uncertain

Towards a theory of producer management

Concern for the management of producers is a relatively recent phenomenon. For the majority of the twentieth century the vertically integrated organization was the ideal for most of the corporate world. However, the increasingly global environment soon brought the inward focus of vertical integration into question. In a series of extremely influential articles (Hamel *et al.*, 1989; Prahalad and Hamel, 1990) it has been argued that organizations cannot 'do it all'. In an era of increasing turbulence, firms must concentrate on their core competencies, and engage in collaborative relationships with other firms. The foundation for identifying and emphasizing core competencies in a multi-firm environment can be traced to Levine and White's (1961) seminal paper on inter-organizational relationships and their concept of organizational domain. In it they argue that organizations dealing in a multi-firm environment must make decisions on the distribution of limited organizational capabilities.

> Under realistic conditions of elemental scarcity, organizations must select, on the basis of expediency or efficiency, particular functions that permit them to achieve their ends as fully as possible. By function is meant a set of interrelated services or activities that are instrumental, or believed to be instrumental, for the realizations of an organization's objectives. (Levine and White, 1961, p. 586)

Given the scope of the functions selected, an organization will choose to operate, at the margins, as a vertically integrated or a 'virtual' organization. These two organizational forms are the endpoints on a continuum where a firm's position will be determined by the functions that the organization chooses to perform internally.

Despite a lack of formal articulation, a focus on core competencies and a virtual form of organization are the standard within the AEC industry. The specialization in design and construction has spawned a host of formal procedures for dealing with the multiple firms that are required to complete a project. It has also spawned an industry where litigation is the norm and managerial decisions are often subordinated to legal concerns (Gibbons, 2007). Although the industry is the archetype for the use of multiple firms there is a limited understanding of the management of these complex structures.

The development of a theory of the management of producers in the built environment draws on three reference disciplines. The first is organizational economics with its focus on contracts. The economics/information approach draws much of its insight from this discipline. The second is TMT that attempts to understand the process and context of trust building between firms. The third is social psychology which recognizes that projects are constructed by individuals that enact the firms' plans.

Managing producers is complex in that it requires the recognition of the formal contractual structures, the informal social structures and the fact that both these structures are embedded in the industry's and firms' individual experience. Doz (1996) identified the crucial managerial issues as involving task definition, partners' routines, interface structure, expectations of performance, behaviour and motive. The process of addressing these issues is important as it allows the parties to start to learn both cognitively and behaviourally about each other. The organizational structure can then be modified to allow for efficiency, effectiveness and equity. The result will be a structure that either facilitates or hinders the integrated relationships that are necessary to create the new knowledge required to resolve the technical and organizational issues that will emerge as the project evolves.

The formal contractual structure

Organizational economics and its counterpart in contract law offer powerful theories for understanding the formal structure of the relationship between firms. This formal structure is memorialized in the contract that creates the temporary organization that governs the project.

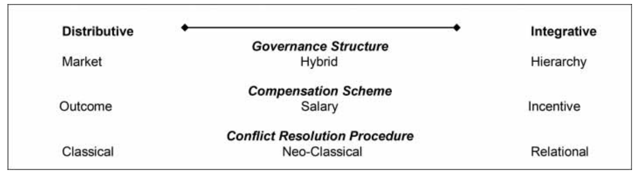

Figure 2 Continuum of contractual components

Drawing on Walton and McKersie's (1965) seminal work, the contractual structure is defined as spanning a continuum from distributive to integrative (Figure 2). A distributive contract is one that is concerned with the division of limited resources. It is oriented towards a zero-sum game. An integrative contract is geared towards identifying, enlarging and acting on common interests. The relationship is a variable sum game with the potential for the outcome exceeding the sum of the parts, with the benefit to the contracting parties being maximized.

Three generic contractual components span this continuum and map to construction-specific components. In the governance structure Market is Traditional Plans and Specs, Hybrid is Construction Management and Hierarchy is Design Build. In the compensation scheme an Outcome is Lump Sum, Salary is Cost plus a fixed fee and Incentive is a Guaranteed Maximum Price with sharing. In the conflict resolution method Classical is the court, Neo-Classical is arbitration and Relational puts the onus on the participants as exemplified by 'Safe Harbor' provisions (ConensusDOCS, 2007). The question becomes whether one should structure a distributive or an integrative contract (Puddicombe, 2009).

Transaction cost economics (TCE) (Williamson, 1975, 1979, 1985, 1991) focuses on governance and addresses the issue of markets or hierarchy. Under this view, sets of exchange conditions call for a specific type of governance structure, which in turn defines the appropriate structure of the relationship. When firms buy and sell with no connections other than the discrete transaction the market (distributive) is deemed most appropriate. The relationships are transitory and governed by perfect price competition. At the opposite end of the continuum, uncertainty, asset specificity and frequency increase, and a hierarchical relation (integrative) is most appropriate. Reviews of empirical research in TCE have found the predictive power of TCE to be substantial (Shelanski and Klein, 1995). However, others (David and Han, 2004) have noted mixed support and have emphasized the need for continued empirical grounding with a focus on the operationalization of the constructs. Researchers (Winch, 1989; Greenwood and Yates, 2006; Puddicombe, 2009), when viewing TCE through an industry specific lens, have shown it to be applicable to a range of issues in the AEC industry.

Compensation schemes are rooted in agency theory (see Eisenhardt, 1989; Baiman, 1990 for extensive reviews) and the seminal work of Jensen and Meckling (1976). They broadly define the theory in terms of the ubiquitous agency relationship, where one party (the principal) delegates work to another (the agent). Turner (2004) suggested that the appropriate form for the compensation scheme depended on project risk, complexity and uncertainty. Baker (1992) proposed a set of three compensation schemes and orders them in a manner that is particularly applicable to a contractual environment. He proposes that as the degree of information asymmetry and the accuracy of performance measures vary different compensation schemes will become dominant. When the performance measures are clear a distributive approach is appropriate. When information asymmetry is high and performance measures are inexact an integrative approach will be most efficient and effective.

The conflict resolution construct in the model is based upon theories of contract law (Macneil, 1974, 1978, 1980, 1981). These theories have come into being as a response to 'the constant clash in modern economic structures between the need for stability and the need to respond to change' (1978, p. 854). Macneil proposes that when a given a set of economic conditions interacts with the specific contractual desires of the contracting parties classical, neo-classical or relational contract law theory will be most appropriate. Presentation, the ability to discount future eventualities, and discreteness, the ability to isolate the parties' interaction are key determinants of the appropriate contract. High levels of presentation and discreteness argue for a classical approach, while low levels argue for a relational approach.

These theories put forth a protocol for choosing the appropriate governance structure, compensation scheme and conflict resolution method for a given project (Puddicombe, 2009). This structure will either hamper or facilitate the learning that is required to achieve the goals and accomplish the tasks demanded by the project. In addition, it will establish the playing field on which firms and individuals will have the opportunity to learn whether they can trust each other.

The informal social structure

Traditional inter-organizational management theory (TMT) and social psychological theory offer powerful lenses for understanding the informal structure of the relationship between firms and individuals.

The focus of much TMT revolves around issues related to an organization's ability to trust another. Ring and Van de Ven (1994, p. 93) have identified two views of trust that are dominant in the TMT literature. One refers to a '… business risk view based on confidence in the predictability of one's expectations …' the other is a '… view based on confidence in another's goodwill'.

DiMaggio and Powell (1983) offer a theoretical perceptive that supports the first view of trust. They argue that forces of institutional isomorphism cause organizations that interact over time to come to resemble each other. The more an organization is like its partner, the greater the organization's confidence in being able to predict an outcome.

Granovetter (1985) develops a theoretical perspective for 'goodwill' from a social and economic perspective. He argues that forces of embeddedness cause individuals to act with goodwill towards their partners. Embeddedness views economic relations as being embedded in a network of personal structures and relationships that discourage malfeasance. Firms are not willing to transact business based solely on a generalized morality or institutional arrangement. Reputation becomes an increasingly important commodity for determining the type of firm interaction. Hill (1990) goes further and argues that the 'invisible hand of the market mechanism' will deselect those individuals and firms that act opportunistically. Not only are the forces to act in a trustworthy manner seen as being significant, they also reduce the pool of the untrustworthy such that a relationship based upon goodwill becomes the norm.

Both trust perspectives argue that institutional and social networks emerge over a period of time. The historic relationship between parties is a crucial determinant of the nature of an inter-organizational relation. Most cooperative relationships emerge incrementally.

Anderson and Narus (1990), examining the effect of trust on cooperation, found, contrary to the prevailing theory, that the causal link appeared to be from cooperation to trust. In order for trust to exist there had to be a history of cooperation between the parties. Individuals and firms need to learn to trust. The trust−cooperation dyad needs to be considered in an evolutionary context (Doz, 1996). In an iterative fashion, small acts of cooperation lead to increased trust which then leads to increased cooperation. This evolutionary perspective is also applicable within a project. In projects some of the most important knowledge that is created surrounds firms' understanding of which other firms can and cannot be trusted, and this emerges over time.

The management of producers requires a strategy that extends beyond the firm level to include the people who take the actions and make the decision. This becomes clear when one recognizes that the major asset that firms bring to the project is people and their capability to create new knowledge. This knowledge takes on many forms but is embedded in the decisions that are made relative to the project. Individuals from different firms often have conflicting goals (Nam and Tatum, 1992) and different thought worlds (Puddicombe, 1997). These differences, which have been identified as major stumbling blocks in achieving superior performance, also offer the opportunity to create new solutions and superior performance. The key is to manage these differences, to focus them on the project and create new knowledge. This is a social psychological process that requires time but can result in congruent purposes, values and expectations and ultimately superior performance.

Ring and Van de Ven (1994) propose that cooperation between individuals from different firms does not just happen. It begins with a process of negotiation where the parties develop joint expectations about risk and trust. This process involves both formal bargaining and informal sense making. The sense making is seen as a form of joint enactment (Weick, 1979) with both parties perceiving the environment in the same way. The language action perspective that Macomber and Howell (2003) have extended into the construction arena offers insights into this process of sense making. This enactment is the social psychological equivalent of the contract's meeting of the minds.

This sense making establishes the psychological contracts that contain the unwritten expectations and assumptions held by each party. It is beneficial for these psychological contracts to contain congruent expectations. They encompass agreements on norms of behaviour, work roles, the nature of the work, security needs and social relationships.

The negotiation process develops the set of initial conditions whereby the learning that results in trust between the parties can begin. These initial contacts are extremely important. These are the first actions of the parties and offer the first concrete evidence as to the actual intent of the parties. Just as with a physical structure, these early encounters act as the foundation for all that comes after.

The producer proposition

As seen above a theory of the management of producers requires the recognition of multiple forces and variation in the project. The choice of the contractual structure defines the formal playing field on which individuals and organizations can learn about the project as well as each other. The trust that exists between organizations and individuals prior to the project and that develops as a result of learning during the project defines the informal playing field. The interaction of contractual, organizational and individual forces creates unique learning environments. The result is the need for different information-processing structures (Galbraith, 1977) resulting in new knowledge, for different types of projects. Drawing on the contingency framework, Figure 3 demonstrates this relationship in terms of the project environment.

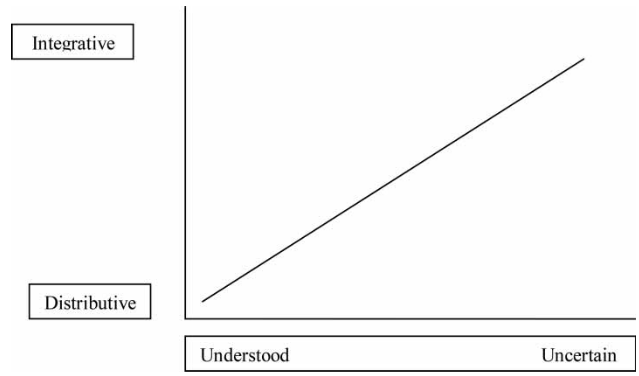

Figure 3 Producer choice

> Proposition 1: The appropriate fit between the project environment and the formal and informal project organizational structure will result in superior performance. As complexity and novelty increase a more integrative structure is required to facilitate the flow of information and the creation of new knowledge.

Towards a theory of production

Projects exhibit a diverse set of characteristics and are enacted in diverse environments. Despite this variety, the management of projects has been dominated by a single prescriptive mind set defined by the PMBOK (PMI, 2008). Recently, there has been significant movement towards a more holistic perspective of project management as exemplified by the work in lean construction. The PMBOK and lean construction jointly inform our efforts to build a theory of production in a construction environment by providing a contrast between a determined and adaptable approach to production (Puddicombe, 2007).

This integrated perspective extends Hayes and Wheelwright's (1984) foundational work in operations strategy, the product–process matrix, into the construction arena. They proposed a strategic match between the characteristics of the product and the capabilities of the process. Within the matrix they positioned a project form of production at one end of a continuum of production alternatives. The PMI has taken the opposite position. They have institutionalized the uniqueness of a project form of production, advocating for the recognition of project management as a unique profession. The perspective presented here takes an inclusive view of the nature of projects. It recognizes that projects by definition are unique undertakings, but within the overall project there are activities that are repetitive in nature. Production management in construction requires an understanding of the range of options available and a strategic perspective.

The nature of projects has resulted in managerial approaches that have had long-lasting impacts, but that are limited in their breadth and depth. The lack of quantifiable and comparable external data has resulted in a quest for the internal control of cost and time. Lord Kelvin's (1826–1907) often-cited comments are particularly relevant to the evolution of project management.

> When you can measure what you are speaking about, and express it in numbers, you know something about it … [otherwise] your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in thought advanced to the stage of science.

Construction project management has endeavoured to be perceived as scientific; unfortunately the numbers that are generated have limited generalizability. As a result project management has stayed focused on the same deterministic, internal cost/time paradigm that was defined in 1910 by Henry Gantt and the Gantt chart and in 1957 when Morgan Walker and James Kelley developed a manageable technique for Critical Path Analysis.

While project management has maintained the status quo (Hodgson, 2002) research in continuous processes has moved far beyond the assembly line to encompass ideas such as lean production, mass customization and supply chain management. The new techniques reflect a realization that efficiency is not enough. The current environment requires production to respond to the vagaries of the customer. Recently, work in construction project management has begun to recognize the potential in these approaches as is evidenced by the introduction of new ideas such as lean construction.

Integration of the PMBOK and lean construction approaches is hampered as a result of political artefacts as well as a fundamentally different perspective of the nature of a project. PMI's efforts to define project management as a distinct profession has resulted in the development of a distinct set of protocols that differ from other producers just as 'doctors differ from lawyers'. Lean construction argues that the construction industry needs to incorporate the cutting-edge approaches developed in the world of continuous operations. Conceptually, the PMBOK views the world of project production as one that can be determined, whereas lean construction accepts that the production process must be adaptable.

Determined

The PMBOK as promulgated by the PMI is widely recognized as the basic reference for project-management practitioners. Its widespread acceptance in the practitioner community has been accompanied by its use as a basic reference point for a significant amount of research in project management (PMI, 2011).

The PMBOK builds on the seminal efforts of Walker and Kelley but attempts to be exhaustive in its coverage of project-management issues. It defines a set of high-level processes similar to those that have been defined as the traditional 'functions of management'. The PMBOK then moves to describe nine areas that purport to describe the realm of project-management knowledge: integration, scope, time, cost, quality, human resources, communication, risk and procurement. It presents an umbrella over knowledge areas that have evolved as distinct disciplines within the study of management. The scope is extensive and the PMBOK's acceptance has been facilitated by the breadth of its approach.

The expansive nature of the PMBOK is driven by the view that the discrete nature of projects presents a set of challenges that are not encountered in continuous operations. Its ability to embrace these divergent areas is facilitated by a perspective of the project environment as one defined by a clear set of characteristics. Although the PMBOK addresses variability in the project it is within a limited set of parameters. This is clearly demonstrated in the introduction to Project Risk Management which states that 'Specific unknown risks cannot be managed proactively … ' and suggests that the appropriate managerial response is limited to allocating a general contingency (PMI, 2008, p. 275). When risk is addressed it has a limited breadth. For example, in scheduling, Program Evaluation and Review Technique (PERT) is employed to accommodate risk. However, the definition of risk is limited (a beta distribution and a defined weighted average definition of time).

The PMBOK definition of a project allows the development of a set of closed-form solutions to project-management issues. The result is that 'planning is the key to success' is an explicit theme of the PMBOK. Given a knowable environment the project manager needs to determine a detailed production plan and then execute that plan.

Adaptable

Many of the underlying principles of lean construction and the PMBOK differ. The emphasis on project management as a distinct discipline, with its roots in Critical Path Analysis, has resulted in a disregard for the managerial revolution that has swept continuous operations. Much of lean construction is rooted in the Toyota production system with its emphasis on quality and the elimination of inventory through the application of Just in Time (JIT) production. The advocates of lean production point out that many production techniques, such as statistical process control and queuing theory, can translate directly to the construction environment when we encounter continuous tasks.

Lean construction recognizes the importance of the areas covered by the PMBOK but it also recognizes the importance of developing approaches that reflect the variety inherent in projects. As projects increase in complexity and novelty, presentation decreases. The increase in possibilities requires approaches that do not assume an ability to plan flawlessly. A particularly powerful example is the Last Planner (Ballard, 2000) method for scheduling. By recognizing that our ability to plan effectively has a finite time horizon, the superiority of a JIT approach to planning becomes evident. Planning now becomes a continuous construction production tool.

Lean production also offers significant insights into the production of building components that are assembled offsite and then integrated into the project. The production of products as diverse as doors and bar joists all benefit from the application of lean techniques. The situation is similar to that which is encountered in the automobile industry where the firm assembles items that are manufactured elsewhere and delivered in a JIT fashion. In the construction process, variability increases, as we integrate components that are site built and components that are site assembled.

The application of lean construction in a project environment shifts the focus from controlling cost and schedule to adding value. It recognizes that projects need to achieve the dual goal of efficiency and effectiveness. A project world defined by complexity and novelty requires a flexible and learning-based approach. Initial planning, while important, does not define the future course of the project. The interaction of the firms at both a managerial and the task level coupled with an environment where many activities are novel, at a minimum introduce the possibility of unplanned events and the requirement for adaptability.

The production proposition

The product–process matrix and the variety in projects suggest that the lean construction and the PMI approaches are complementary and each has a place in the management of construction production. Evidence suggests that when dealing with the production of items that will be produced off site or with on-site tasks that are repetitive, that lean production offers significant advantages (Ballard, 2000). The issue then becomes the management of activities that are discrete in nature. Ballard and Tommelein (2012) suggest that as projects increase in complexity management needs to become less prescriptive and more adaptable.

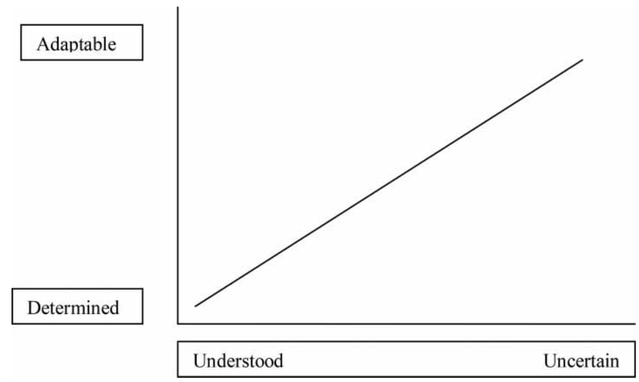

Figure 4 Production choice

The logic of the product–process matrix can be modified to augment the project end of the matrix. We can develop a project-process matrix that suggests that given different sets of project characteristics, we need to select different project production techniques. This emphasis on strategic choice echoes Gidado (1996) who observed that appropriate managerial actions can mitigate the effect of project complexity on the construction production process. These techniques can be generalized as adaptable (lean) or determined (PMBOK). Figure 4 illustrates the relationship between project environments and production choices.

> Proposition 2: The appropriate fit between the project environment and the production regime will result in superior performance. As complexity and novelty increase an adaptable approach will be most efficacious. With projects that are understood, a deterministic approach is appropriate.

Towards a theory of planning

Despite the distinct theoretical treatments of producers and production they should not be treated as a separate decision area. Successful construction management requires a strategic alignment between the two areas. Recognizing management as a process of knowledge creation and complexity and novelty as variables common to all projects allows us to develop a generic strategic management model. When we are dealing with an understood project there is little necessity for the creation of new knowledge and control may be effective. When we are dealing with uncertainty control gives way to the need to learn throughout the duration of the project (Puddicombe, 2006).

The discussion of learning has its basis in the work of Polanyi (1958) and its extension into the business world by Nonaka and Takeuchi (1995) who define knowledge as existing in two forms: explicit and tacit. Explicit knowledge is that which is codifiable. It can be explicitly defined and captured in a concrete form. Plans and specifications are expressions of explicit knowledge. Tacit knowledge is something that is not easily expressed and is hard to formalize. The ability of the project manager to deal with a recalcitrant subcontractor or to intuitively re-schedule a set of complex activities that are delaying the project is an expression of tacit knowledge. However, new knowledge is rarely created by a single individual, but rather by the interaction of individuals. This interaction involves the conversion of knowledge from one form to another (Figure 5).

The specific realization of this knowledge conversion process will vary from project to project. However, we can develop some generic example. Socialization could describe the informal process by which the various actors learn to deal with each other. The underlying belief systems of the individuals will interact, resulting in a management process defined by adversity or collaboration. Internalization would be reflected in the development of the firms' underlying belief in the trustworthiness of each other as a result of the formal contracts. Externalization describes the process by which the architect translates the owner's thoughts into a set of plans and specifications. Combination describes the translation of the architect's plans and specifications into the contractor's budget and schedule.

The advent of new technologies that fall under the generic label of building information modelling (BIM) are creating new opportunities for knowledge creation. However, new technologies also require new processes. Sage *et al.* (2010), drawing on actor–network theory, demonstrate that the interaction of human actors with technologies can have a significant effect on the process of knowledge creation in construction management. This socio-material association is evident in the evolution of BIM technology where its implementation in VDC requires a re-engineering of AEC practices (Mihindu and Arayici, 2008). Previously, learning often occurred as isolated events and while BIM can be implemented in a limited context and at a purely explicit level its potential is realized when it becomes a tool for integrated learning. The development of the model results in the explicit learning described by externalization and combinations. The process by which the actors come together in VDC facilitates the tacit learning of socialization and internalization. The emergence of collocation as a VDC strategy demonstrates the importance of both types of learning. The implementation of VDC and BIM also holds promise for altering the timing of learning. The industry now has the potential to simulate the design/ build process and engage in learning from a virtual process. This is a process that will accelerate learning about the project. Issues that were previously addressed individually as they physically emerged can now be dealt with holistically as part of an early virtual planning process.

	Tacit knowledge To Explicit knowledge	
Tacit Knowledge	Socialization	Externalization
From		
Explicit Knowledge	Internalization	Combination

Figure 5 Knowledge conversion adapted from Nonaka and Takeuchi (1995)

The planning proposition

Construction management has traditionally been concerned with control. This would suggest that the synergy between theories of producers and production would be concerned with increasing control. However recent research (Puddicombe, 2006; Carroll and Burton, 2012) suggests that ongoing learning and knowledge creation throughout the project is the key. This knowledge serves to facilitate the process of planning and execution at both the producer and the production level. The process by which new knowledge is created is planning. However, this is not planning that is limited to the traditional pursuit of attempting to control the future. It is also planning that recognizes the need to learn. Figure 6 shows the relationship between project environments and planning.

> Proposition 3: The appropriate fit between the project environment and the planning regime will result in superior performance. The more complex and novel the project the more it becomes necessary to institute a process that facilitates knowledge creation.

Strategic construction management: producers, production and planning

When planning is defined as an exercise in learning, the management of the construction project becomes a

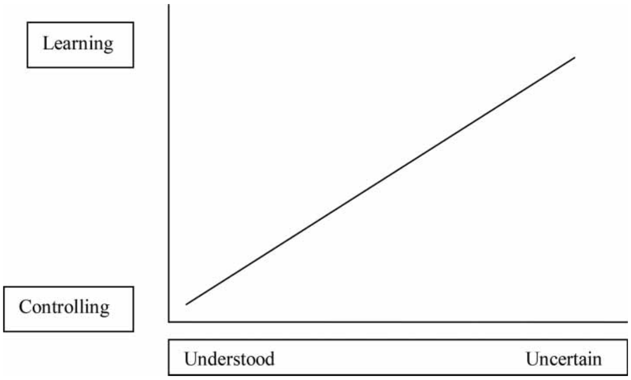

Figure 6 Planning choice

much more complex process. As opposed to the directional path of project-management tools such as critical path method (CPM), this view sees the management of the project as an iterative process with many feedback loops. The decisions made relative to the management of producers define the initial characteristics of the planning process. The management of production results from the planning process. This process can then either follow a model centered on controlling or learning. Controlling involves a linear process of planning–execution–performance. The learning process involves a cybernetic approach (Puddicombe, 2006) that sees learning resulting from each step in the process. As we plan we will learn about the participants in the planning process and that will affect future planning. As we execute the plan we will learn and modify the execution strategy as it is enacted. In addition, the learning that results from the execution will modify the planning process. The process of execution is where we will see evidence of the technical capabilities of the various actors as well as actions that validates our beliefs as to commitment of the firms to the project requirements. After we execute we will measure performance. This presents us with hard evidence as to the validity of both our execution tactics and our planning strategies. We will then either modify these tactics and strategies or continue with the current process.

In the final analysis project success will result from decisions informed by the actual as well as the planned reality of the project. Figure 7 presents a

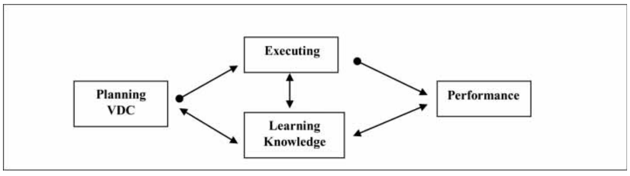

Figure 7 Knowledge based construction management

model of the management of projects as a process of learning and knowledge creation.

The challenge in the AEC industry is brought into sharp focus when one recognized that the management of producers and production cannot be treated as discrete activities. Given that the actual production is completed by multiple firms it becomes clear that the organizational structure that joins these firms is critical if the actual work is to be completed successfully. By the same token, creating an organizational structure does not build the project. There needs to be a strategy for the production and the producers and more importantly there needs to be synergy between the two strategies. A production plan that achieves the ongoing as well as the overall project goals is necessary.

The strategic options are consolidated in Table 1. Those associated with an understood environment, distributive, determined and control (DDC) are the standard operating procedure for much of the AEC industry and are in fact mandated by many state and federal agencies. Due to its prevailing position DDC is generally efficient to execute. The alternative strategies, integrative, adaptable and learning (IAL), which are suggested for an uncertain environment, are emerging. There are significant organizational, technological and legal issues that have not been fully resolved. The result is that at present, they may not be as efficient to execute. In addition, the IAL approach requires that more resources be extended on the front end of the project. However, the efficiency of the firms' operations is only one factor in determining project performance. The strategy also needs to be effective in that it achieves the project's goals. The choice of the DDC or IAL is then seen to be a strategic choice with economic effects on both the firm and the project. In Figure 8, the three propositions are consolidated in a single strategic model that suggests that a fit between the project environment and the producer, production and planning strategies is required if superior performance is to be achieved.

Table 1 Strategic decisions and alternatives

Theory	Construct	Variable
Contingency	Project environment	Understood Uncertain
Producer	Organizational structure	Distributive Integrative
Production	Production regime	Determined Adaptable
Planning	Planning regime	Control Learning

In practical terms, Figure 8 suggests some explicit strategies. An understood project environment would fit with the DDC approach and a traditional linear Plan, Bid, Build process. The use of a distributed contract AIA A101 (Standard Form of Agreement between Owner and Contractor where the basis of payment is a Stipulated Sum) contract would be appropriate. This would be accompanied by the formal application of the PMBOK, with schedule control via CPM and cost control via stipulated sum contracts. If the project is understood, requests for information (RFIs) and change orders would be minimized. Project objectives would be achieved in the most efficient and effective manner. The figure also suggests that if the IAL strategies are implemented in an understood environment relative performance would decrease. The expenditure of resources on IAL would result in decreased efficiency without an increase in the effectiveness of firm and project performance.

At the opposite end of the spectrum an uncertain project environment would fit with an IAL approach that combined planning, designing and building. The use of an AIA C195 (Standard Form Single Purpose Entity Agreement for Integrated Project Delivery) would be appropriate. This would be accompanied by lean construction techniques such as Last Planner (Ballard, 2000) and control resulting from learning. The learning would be facilitated by the application of VDC involving all the appropriate stakeholders. By acknowledging the uncertainty and organizing for its affects, RFIs and change orders would be minimized and the project objectives would be achieved in the most efficient and effective manner. Figure 8 also suggests that if the DDC strategies are implemented in an uncertain environment relative performance would decrease. The efficiencies that DDC experiences in an understood environment would not materialize and would be accompanied by a decrease in effectiveness that resulted from impediments to learning.

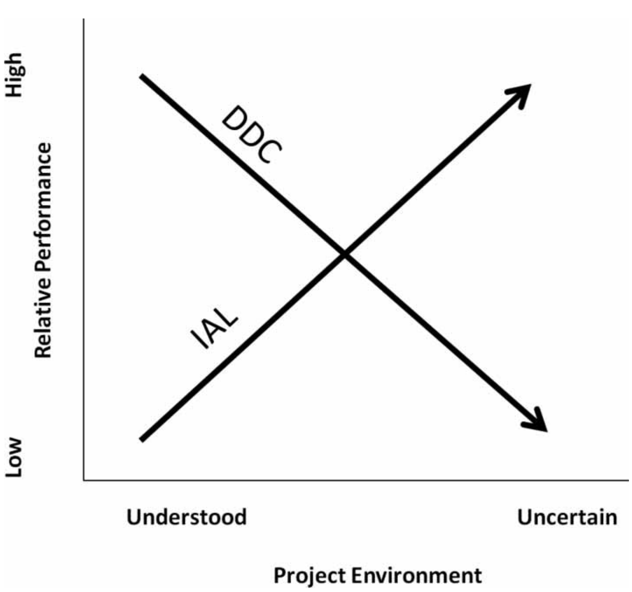

Figure 8 Integrated strategy model

Discussion

The variability in the potential structure of construction projects makes the application of a single theoretical model inappropriate. Indeed any single project may be so diverse that it requires the application of multiple perspectives to achieve success. One of the attractive features of the PMBOK approach is that it attempts to organize this diversity. However, its efforts are constrained by a deterministic view of the project. This paper has offered a framework that places no such limitation on the project. As a result it does not offer a comfortable closed-form solution but rather a challenging holistic perspective of the project that requires the mangers of a project to operate at both a strategic and a tactical level. They must be concerned with the management of producers, the management of production and the interaction of the two. The framework also proposes that in addition to managing tasks the manager of a project needs to manage learning and knowledge creation. Finally, order is imposed on these multiple demands by suggesting that the degree of complexity and novelty can serve as vehicles to aid in the decision-making process.

In formalizing these strategies the framework also serves as a vehicle to develop a synergy between the various research streams that have previously resisted integration. Lean construction (Koskela and Ballard, 2006) and the 'economics/information approach' (Winch, 2006) are seen as addressing different facets of construction management. Lean construction and the PMBOK (PMI, 2008) are appropriate for different types of projects. Additional research streams also gain relevancy as they can be seen to apply to different strategic areas.

Underlying this model is an assumption about the nature of the project environments and our ability to mitigate or shift the hazards associated with those environments. In a project with low complexity and novelty the world is understood, information asymmetry is weak, performance measures are clear and the possibilities are easily defined. The players can make informed decisions as to the allocation of costs and benefits early in the project and facilitate the management process. In a project with high complexity and novelty the world is uncertain, information asymmetry is high, performance measures may be weak and therefore the nature, the magnitude and the value of the possibilities are unknown. The result is that ex ante allocation of costs and benefits would not be economical, and could hinder the management process as the actual nature of the project emerges. At the margins this model suggests very different sets of conditions. Decisions related to producers, production and planning should reflect this reality.

The model of relative performance shown in Figure 8 proposes explicit outcomes associated with specific strategic decisions and specific project environments. The overall validity of and the specific form of the models is still open to question. It is argued that synergy between the constructs results in superior performance, but the specific form of the interaction between the constructs is not defined. What is the effect of an approach that combines elements of DDC and IAL? In addition, this paper proposes models for environments on the margins. What strategies are appropriate for the intermediate Risky and Ambiguous environments? Will an approach that combines an integrative producer strategy and a planning regime based on control be most efficient and effective?

The strategy model offers a much more comprehensive perspective than is common in the construction project-management literature. It integrates theories that have previously maintained distinctive perspectives. However, many of its suggestions are contrary to dominant industry practices. This suggests that despite the underlying theoretical basis, parts of this model may not withstand detailed empirical examination.

Conclusion

A unique opportunity and constraint exists in the construction industry in that each project offers the opportunity and challenge to create a new strategy. An additional constraint is also present in that no single firm determines all these strategies. The owner is generally responsible for defining the structure that links the triad; the producer strategy. Traditionally, the Contractor is responsible for the means and methods, the production strategy. In addition, this production strategy needs to embody a second producer strategy to address the relationship between those firms (subcontractors and suppliers) that actually produce the product. Finally, the planning process needs to support these choices and focus on learning as well as controlling.

While there are multiple areas for future research two important themes emerge from the discussion. The first is the validity of the contingency perspective. Distinct approaches to construction project management that operationalize the range of strategic decisions are presented in the discussion of Figure 8. These approaches together with the contingency construct, project environment, suggest a fit that results in superior performance. The second is the argument that there should be integrated decision-making related to producers, production and planning. These are distinct constructs and it is likely that their relative importance will vary with individual projects. Understanding these weights becomes more important, when, as previously described, these decisions are made by different actors. This suggests that the final enacted strategy could reflect optimization at the actor not the project level.

The paper has presented significant opportunities for ongoing research. The explicit nature of the models and propositions lend themselves to the development of a rich set of hypotheses that can be subjected to empirical analysis and falsification (Popper, 1965). This is the important next step.

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