STRUCTURING IDEAL PROJECT DELIVERY SYSTEM

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This paper proposes a method for answering the question, “What is the best Project Delivery System (PDS) disregarding context?” Its starting point is a critique of previous literature for failing to adequately consider organizational integration and managerial operating systems when defining project delivery systems. The proposed research method is statistical analysis of survey data, exploring the correlation between hypothesized characteristics of the ‘ideal’ PDS and outcomes. The hypothesized characteristics are alignment of stakeholder interests, organizational integration, and lean production management. The hypothesized Ideal PDS might not be generally applicable to public sector now, but the successful outcome of the hypothesis testing, as a continuation of this paper, would provide evidence in support of changing public agency procurement practices and regulations.

INTRODUCTION

Current definitions of project delivery systems are shown in Table 1.

Table 1: Definitions of a PDS

Ibbs et al. (2003)	Project delivery system is D/B/B, or D/B with different contractual strategies such as Lump sum, cost plus fee, GMP, and so on
Cingle Ⅲ et al. (2010)	Project delivery system is Cross functional business process used for the selection, development, and delivery of capital project. <Three objectives with this definition> 1. Promote a discovery–driven process to facilitate investment development that supports business objectives and strategies 2. Improve cross functional participation in the PDS in terms of timely involvement of project sponsors and project users (operation and maintenance)

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	3. Promote sustainability by providing more comprehensive guide lines, best practices, and tools for the engineering work forces.
Airport owner's guide (2006)	A project delivery system is defined as 'the arrangement of relationships among the various parties involved in the design and construction of a project that establish the scope and distribution of responsibility and risk'; It establishes responsibility for how the project is delivered to the owner. The project delivery system defines who is responsible for each of the various phases of the project.
AGC (2004)	A PDS is the comprehensive process of assigning the contractual responsibilities for designing and construction of a project. The criteria defining a PDS are 1) Whether design and construction have separate contracts with owner, and 2) Whether minimum price is the only Criterion used in procurement of constructor
Thomsen C. (2006)[5]	A Project delivery process is the sequence of defining responsibility, scope, and compensation. The four criteria defining a PDS 1) contractor selection criteria (qualification, price, or mixed) 2) number of contracts-between design and construction (integrated, separate, multiple prime, or direct procurement) 3) Type of relationship with owner (a service such as program management provider, a provider of service and product, a product provider) 4) Terms of payment (time and material, target price with incentives, cost plus with a Guaranteed Maximum Price (GMP), unit price, fixed price)
Sanvido et al. (1998)	A project delivery system is the relationships, roles, and responsibilities of the parties and sequence of activities required to provide a facility
Ireland, V. (1982)	PDSs describes the roles of participants, the relationships among them, both formal and informal, the timing of events, practices and techniques of management that are used

An analysis of Table 1 suggests that design of a specific PDS could be addressed by determining 1) Criteria for selecting contractors, 2) The degree of contractual integration between design and construction, 3) Contractor's relation with owner such as product provider, service provider, or mixed, 4) Payment types such as lump sum, unit cost, cost plus fee, cost with GMP, target price with incentives, material or time, and so on, 4) relationships among participants including formal and informal, and 5) practices/technologies of management. However, these are not completely taken into account in currently used forms of PDS

5 I could not find this article but find some traces of it through web searching. This definition is quoted from L. Greg et al. (2008)

Table 2 shows that, apart from Integrated Project Delivery (IPD), current PDSs do not fully consider organizational structure and management practices, The focus is rather that of procurement rather than project planning; with attention paid to methods of selection and allocation of responsibilities.

Table2: the current PDSs

Name of PDS	**Features** (reference)
Indefinite delivery/indefinite quantity (ID/IQ)	Quantity, supplied at the contracted price, or exact location are not specified (Trauner, 2007)
Agency Construction Management (Agency CM)	There is a separate consultant as CM other than architect and contractor, who is not responsible for construction cost risks (Trauner, 2007)
Multi prime approach of Design-Bid-Build	A CM manages multiple contractual relations between the owner and several contractors instead of general contractor but is not responsible for the construction cost (Gehrig, 2009)
Construction Management at Risk (CM @ R)	The General Contractor (GC), as a CM, is responsible for cost overrun over Guaranteed Maximum Price (GMP), and is involved in the pre-construction processes (Trauner, 2007);
Portland Method	A kind of CM @ R, but the contractual cost, named as Estimated Reimbursable Cost (ERC) is determined later than GMP, usually determined in early phase of the design, in order to increase cost certainty (Trauner, 2007)
Design Sequencing	GC can start construction of a phase as soon as the design of the phase is completed, while the design of the next phase is ongoing. But, the GC usually does not participate in making design of the project (Caltrans, 2004)
Early Involvement of Contractor and Target Pricing (EIC)	A kind of DB. But it lets GC involved in the pre-design phase and uses target pricing with fiscal incentives combined with open account instead of lump sum price, used in a usual DB (Trauner, 2007)
Project alliancing	It selects the whole project alliancing team including architect, GC, and key special contractors based on criteria other than minimum price for construction at the beginning of the project, uses Limb 3 principle[6] to set pain / gain share mechanism, and adopts open account and unanimous decision making system (Matthew, 2005)
Integrated Project Delivery (IPD)	A single agreement among all participants, waiver of right of all participants to sue any of other members

[6] Limb 1 cost: all direct costs of the project and project specific overhead incurred by the alliance team members; Limb 2 fee: corporate overhead and profit, a fixed lump sum set as percentage of the target cost, this is the maximum financial loss of the non owner parties; Limb 3 fee: distributed fee among members of the alliance team from the total difference between Limb1 cost and target cost according to the predetermined principles

	until the completion of project, early involvement of specialty contractors in design phase, and incentives and disincentives with target price (Gehrig, 2009)
Design Build and Design Bid Build	Too famous to be specified

Thomsen et al. (2009) already addressed a similar concern by saying that all PDSs have three basic domains-the project organization, project's operating system, and the commercial terms binding the project participants. And also Thomsen et al. (2009) claimed that traditional PDSs have failed to integrate the participants organizationally (owner, designer, and contractor), have erred in assuming conventional wisdom regarding the trade-offs among time, cost, and quality as natural and unavoidable, have structured contracts in a way that discourages collaboration across contracts, with each party seeking its own interests at the expense of others, or of project performance as a whole.

When there is a considerable difference in performance among those projects which employ commercially similar PDS as explained in Table 2, we can guess there are hidden explanatory variables other than traditional commercial components. And the existence of the hidden factors are coincident with Thomsen et al. (2009)'s assertion about the three components of a PDS.

Relevant research for this supposition includes Sanvido et al (1999), which investigated 315 projects and concluded that Design-Build (DB) achieved lower unit cost, faster construction speed, faster delivery speed, less cost growth, and less schedule growth than DBB and CM-at-Risk. However, Ibbs et al (2003) found DBB projects experienced positive changes by 0.4% reduction of cost while DB projects experienced negative changes by 7.4% increase of cost. Similar research was done earlier by Konchar et al (1998), which showed that DB projects experience 5.2% less changes than DBB, upporting the extended use of DB. These contradictory research findings may indicate that presence of hidden variables determining project performance in spite of similar commercial characters.

OUR DEFINITION OF PDS

We adopted the Thomsen et al. (2009)'s definition about the fundamental components of a PDS 1) commercial terms, which is the combination of procurement of contractors, variation in integrating design and construction, contractor's relation with owner (service or product provider), and types of payment; 2) organizational structure, which would be classified by the degree of integration among participants in terms of involvement in various decision making; and 3) management system, which is characterized on a continuum between sole reliance on Management By Result (MBR) in which managers establish financial goals and monitor performance against the goals (Ballard et al., 2004) and Management By Means (MBM) in which managers create and maintain the means for sustained performance, relying on process measures for feedback on system performance, the ‘means’ (Ballard et al., 2004). Even though there could be various kinds of MBM, we decided to adopt Toyota lean production theory as MBM in this research, following Johnson & Broms (2000).

It is apparent that for a given project, there may be conditions that prevent complete realization of the ideal project delivery system; conditions such as regulatory restrictions on commercial terms, or inability or unwillingness of project team members to embrace aligned incentives, integrated organizations, or a lean operating system. However, if project delivery systems that contain specific components produce better outcomes than systems that do not contain those components, those components can be specified as necessary for an Ideal PDS.

Before going into deeper discussion on the Ideal PDS, we should address how performance is to be measured; against what outcomes. After some literature review, we concluded that the Commonly Acknowledged Performance (CAP) are cost performance, schedule performance, safety factors, defects, and subjective satisfaction (overall quality of product, reliability of processes, non owner’s part satisfaction, problem solving, leadership, and so on). Construction Industry Institute (CII, 2008) defines cost factors, duration factors, Lost Work Day Case Incidence Rate, and Recordable Incidents Rate as performance indicators. The U.K.’s *Rethinking Construction* (CTF, 1998) capital cost, decrease of construction time, increase of predictability, decrease of accidents, increase of productivity, and increase of turnover & profits as targets for improvement (CTF, 1998). The Danish benchmarking system defined actual construction time versus planned time, change of total price and unit price, accident frequency, number of defects, remediation defects after handing over, and customer satisfaction, as key performance indicators (Cheung et al., 2004). Similarly, individual researchers have defined their own performance indicators as results of investigation or addition of new concepts on these UK’s, Danish, or CII’s indicators. The web based Project Performance Monitoring System (PPMS), developed by Cheung et al (2004), defines time factors, cost factors, accident factors, defect factors, and satisfaction factors as project performance indicators. Chan et al. (2004) also developed similar performance.

In short, our research’s purpose is to find the PDSs’ components that have enable achievement of better CAP than those not employ the components. Figure 1 show the process of designing a PDS and this paper’s purpose is to find the zone of Ideal PDS in Figure 1.

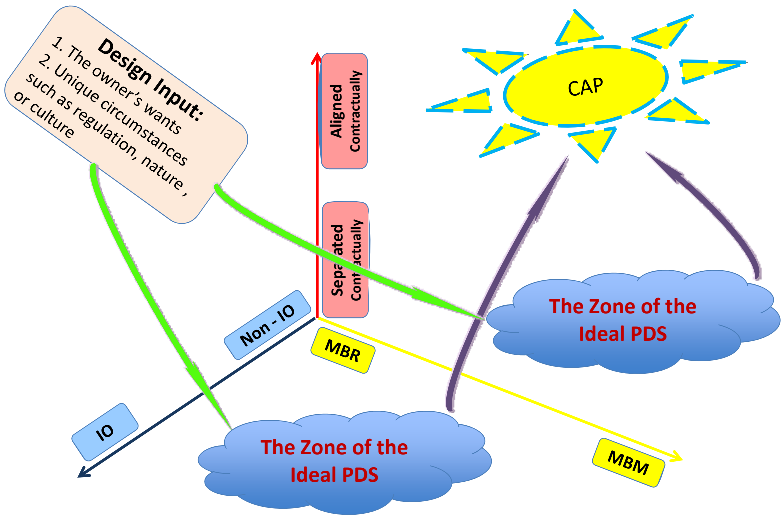

Figure 1: Designing a PDS

RESEARCH METHODOLOGY

IPD is a practical movement realizing Ideal PDS. IPD structures commercial terms to align all participants' interest, employs an integrated organizational structure, and uses Lean construction tools, an instance of MBM, as the operating or management system (Thomsen et al., 2009). IPD has achieved successful outcomes on several projects. Cohen et al. (2010) analyzed six projects with six representative IPD criteria: early involvement, shared risk and reward, multi party contract, collaborative decision making, liability waivers, and jointly developed goals.

Table 3: the performance comparison among IPD Projects

	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6
Early involvement of participant	Yes	Yes	Yes	Yes	Yes	Yes
Shared risk and reward	Yes	No	Yes	No	Yes	No
Multi Party contract	Yes	Yes	Yes	Yes	Yes	No
Collaborative decision making	Yes	Yes	Yes	Yes	Yes	Yes
Liability waive	Yes	No	No	No	No	No
Jointly developed goal	Yes	Yes	No	Yes	Yes	Yes
Unit cost	242.51	277.89	330.24	365.69	245.82	313.48

(construction + design): $/SF						
(Planned cost-Actual cost)/planned cost in Construction (%)	0.87	4.76	3.037	0	3.06	-7.61
(Planned cost-Actual Cost)/planned cost in Design (%)	0.81	The upper is total rate	n/a	-1.12	-9.82	-4.62

The Unit cost and cost reduction rate were made by us based on the data of Cohen et al. (2010). When we did regression of the number of ‘Yes’ on Unit cost using STATA, the regression coefficient is -32.72 and constant is 437.72. Thus, approximately, Unit cost = -32.72×number of ‘Yes’ + 437.72. And correlation coefficient is -0.6886 between the two variables. However, there is no statistical significance in either regression or correlation findings. Given the small dataset, we cannot say unit cost is the absolute criteria in measuring performance, but the concept used in the above calculation is adopted in our research. Our research’s goal is to select many more cases than six in Table 3, then test our research hypothesis through statistical analysis of case data.

The research hypothesis is that project delivery systems perform best when they:

1) Align the interests of the parties to the delivery of maximum value to the client and stakeholders within their conditions of satisfaction (time, cost, location, regulations, customs, etc.)

2) Integrate the parties organizationally, so that upstream players are involved in downstream processes and downstream players are involved in upstream processes

3) are executed with a management-by-means philosophy, principles, and methods (specifically, it employs lean production theory)

Each component of the hypothesis will be specified by measurable indicators. We summarize the indicators based on relevant references in Table 4.

Table 4: Indicators of Ideal PDS made by our research team

Hypothesis	**Indicators**
1. Alignment	1) Performance based selection of contractors 2) Investigating market cost, duration, and functionality (Ballard, 2006) 3) Setting target cost, duration, and functionality less

	than market values to promote innovation, and sharing cost savings and risk of cost/time overrun (Sakal, 2005) 4) Risk allocation among participants (CII, 2008)
2. Integrated organization	1) Participation of contractors in the investigation market values (Ballard, 2006) 2) Participation of contractors in setting the Target values (Ballard, 2006) 3) Participation of contractors in risk allocation (Ballard, 2006[7]) 4) Participation of contractors in design (Saunders et al., 2005) 5) Participation of each project participant in process designing regarding its own work (Ballard et al., 2003) 6) Distributed power to project participants to correct errors and omissions when found. (Ballard et al., 2003)
3. MBM-Lean Production Methods	1) Investigation of design alternatives; set-based design (Ballard, 2000-a) 2) Collaborative sizing and allocation of time buffers in phase scheduling (Ballard et al., 2003) 4) Narrowing down design alternatives based on evaluation against time and cost constraints (Ballard, 2000-a) 5) Concurrent product and process design[8] 6) Preassembly in process design (Tsao et al., 2001) 7) Minimizing batch sizes (Arbulu et al., 2002) 8) Inventory management (Walsh et al., 2004) 9) Standardization of products and processes (Tommelein, 2006) 10) Use of pull mechanisms for controlling the selection and release of work to immediate customers (Tommelein, 1998) 11) Instant communication channels between adjacent processes (Tommelein, 1998) 12) Analysis and action on constraints on scheduled tasks (Ballard et al., 2003) 13) Corrective and preventive action on causes of breakdowns, including plan failures (Ballard, 2000-b)

With data from enough projects, we can use a large N survey as the measurement of indicators in Table 4 in order to find the correlation between the indicators and CAP in Figure 1. However, we should consider the difficulty of gathering data through a large N (number of cases) survey. For example, even though Victor et al (1999) gathered data from 378 projects, those are only 5.1% of the total population

[7] Ballard (2006) explained the collaborative allocation of target cost to facility systems. We regard this process as a form of risk/reward allocation.
[8] It came from our research team discussion

(7,600 projects). The next option is to use datasets already in existence, such as those collected for benchmarking purposes. An example is the Construction Industry Institute (U.S.A.) benchmarking database. Unfortunately, the databases we have identified do not adequately characterize the operating system used for project delivery. To solve this problem, we will supplement the large N statistical analysis with statistical analysis of data from a smaller population, plus anecdotal data (case studies) and logical argument.

SUMMARY AND CONCLUSIONS

Through this paper, we urge that the currently used definitions of PDS are not sufficient to address whole characters of a project such as needed organizational structure or management philosophy and suggest the form of Ideal PDS including contractual alignment, integrated organization, and Lean production system as MBM. Consequently, we created the research methodology to support our suggestion. The hypothesized lean PDS are generally not available to public agencies, and when available, or not much used. If we can show through our research that they produce better outcomes, that would provide evidence in support of changing public agency procurement practices and regulations.

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