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An Evidence-Based Comparison of Project Delivery

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Evidence-based decision theory is a process to identify uncertainty and knowledge about a problem through research and practical knowledge. This research used the analysis-of-variance (ANOVA) method to analyze the risks associated with economics, environment, project, and technology on the project delivery methods of design-bid-build and design-build from the perspective of professionals in the construction industry. Data collected from this research was used to develop an evidence-based risk model related to the constructs of economics, environment, project, and technological risk and compare them between the two project delivery method variables of design-bid-build and design-build. Findings included significant differences across the constructs of project and technology. Additional findings on cost and time exposed differences associated with expectations of change and the understanding of costs within the design-build delivery method. For the design-bid-build project delivery method, the research confirmed the concern about cost growth through change orders. With design-build, the research supported the concept of improved quality and a better understanding of cost during the design process. Conclusions from this research provide construction managers associated with the ownership, design, and construction of projects with information about areas and magnitudes of potential risk concerning the two project delivery methods investigated.

Key Words: Evidence-Based, Risk, Project Delivery, Design-Bid-Build, Design-Build

Introduction

Medical professionals have used a gestalt process to analyze information by weighting individual pieces of information related to patient condition, resources, budget, experiential knowledge, and econometrics, to analyze the risks to a patient. Evidence-based project delivery is very similar in nature where projects must be analyzed using synthesized information compiled by engineers, architects, constructors, and numerous consultants to provide a project within a defined budget, time duration, specified quality level, and meets or exceeds safety standards creating a level of complexity that is managed by several professionals with specialized knowledge.

Many construction project delivery methods and variations exist to organize and complete the activities required on a construction project. The most dominant and traditional project delivery method today is still the design-bid-build (DBB) method (Kubba, 2017). Although there are many delivery methods, literature on DBB as a project delivery method has identified the fact that it is a well-established practice in the construction industry and is very sequential in nature showing clear delineations between the processes of design, estimating, project procurement, and actual construction. Therefore, the risks associated with this delivery method are also well-established and known throughout the industry (Mick, Johnson, & Gaughan, 2023, Gould & Joyce, 2003).

The use of design-build (DB) as a delivery method to manage projects does provide many challenges for project teams. For the owner, the DB method allows a single point of contact for the design and construction of a project. This is unlike the design-bid-build method, where the owner contracts separately with an architect and/or engineer to manage the design of the project, and with a constructor to manage the physical construction. With design-build the project sequencing also changes due to the fact that design can happen concurrently with the construction of the project (Kenig, 2011, Mick, Johnson, & Gaughan, 2023, Ying et al, 2002, Trombitas Barrazato, & Beardall, 2020). Trombitas, Barrazotto, and Beardall (2020) also identify the fact that effective collaboration and project execution are critical where owners face drastic budget shortfalls and resource constraints, especially in the current market.

In comparing these two delivery methods, the literature suggests that there are inherent risks associated with cost and time related to both design-bid-build and design-build (Beard et. al., 2019, Konchar & Sanvido, 1998, Ying et al., 2002). Statistical-analysis procedures show there are inherent differences between the two delivery methods (Ibrahim, Hanna, & Kievet, 2020). The relationship of construction as it relates to DBB and DB and the influences each has on the metrics of cost and time bears an element of significance. The importance of the relationship between the two methods, cost, and time, is that each delivery method and project have its own inherent unique characteristics. One method DBB has a fragmented management system, and the other DB is an integrated management system (Konchar & Sanvido, 1998, Park & Kwak, 2017, Yates and Battersby, 2003).

While the characteristics change with every project and project team. A comparison can be made with the roles and responsibilities associated with the management of the project change between the owner and constructor. Under the design-bid-build method the roles are similarly defined to the list shown below in Table 1 and Table 2:

Table 1

Comparison of Roles and Responsibilities for Design-Bid-Build

Owner	**Contractor**
• Design • Environmental analysis and approvals • Coordination with other governmental entities (if needed) • Design standards • Finance planning and management • Quality assurance and quality control • Independent quality assurance • Coordination between the designer and the constructor • Management oversight • Utility coordination • Public information/relations- strategic and tactical	• Project construction • Project management • Site safety • Coordination and management of subcontractors

Adapted from: Tom Warne and Associates (Warne, 2005)

Table 2

Comparison of Roles and Responsibilities for Design-Build

Owner	**Design-Build Contractor**
• Design oversight • Initial coordination with governmental entities • Preliminary design • Independent quality assurance • Public information/relations- strategic • Environmental analysis and approvals • Government relations- strategic • Right-of-way acquisition • Definition of project attributes and characteristics • Finance planning and management	• Project construction • Project management • Design • Design management • Public information/relations- tactical • Environmental mitigation and compliance • Detailed coordination with governmental entities • Quality assurance and quality control • Right-of-way acquisition • Coordination between designer and the constructor • Quantity management • Performance management • Utility coordination • Site safety • Coordination and management of subcontractors • Financial management and cash flow

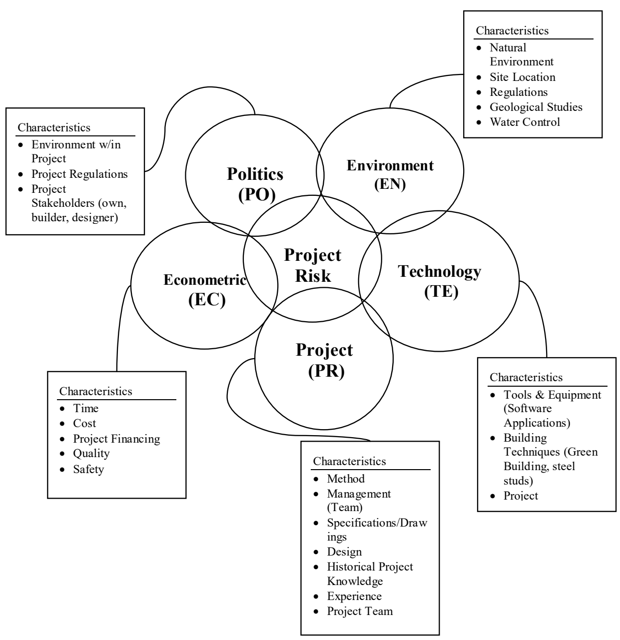
Adapted from: Tom Warne and Associates (Warne, 2005).

The process of construction is a series of carefully planned events executed in the field to manage cost, time, quality, and safety. The contrast in roles and responsibilities to manage risk are different with respect to the two different delivery methods (Kubba, 2017 & Warne, 2005).

Methodology

The design of this research used two project delivery methods and continuums established by Davies (2004) with the concepts on evidence-based inquiry provided by McMillan and Schumacher (2006) to validate and expand upon its conceptual model as it applies to construction project delivery. Shown in the Figure below illustrates how the five factors that drive this research interact, affect construction project delivery, and potentially impact construction risk.

The study included both independent and dependent variables. The independent variables for this study included the two project delivery methods: DBB and DB. Participants in this study voluntarily selected surveys on DBB or DB, depending on their experience with these methods, such as the number of years they have worked with these methods, or the number of projects they have built with either DBB or DB. Participants that had extensive experience with and knowledge of both delivery methods were asked to complete both surveys. Dependent measures include the five constructs of economics, environment, politics, project, and technology. Items related to the five constructs were randomly organized throughout each of the two questionnaire forms. Responses depended on each participant's experience with the delivery method. A conceptual model is shown in Figure 1.



Adapted from Davies (2004)
Figure 1. Conceptual Model of Project Complexity

Study Phasing

The significance of this study is that it measures and compares potential risks associated with these two project delivery methods across the five constructs of interest, through measuring the perceptions of experienced professionals in architecture, engineering, and construction disciplines. This is important since the delivery of a construction project involves the process of identifying the scope, procedures, actions, contractual requirements, events, relationships between participants, mechanisms for managing time, cost, safety, and quality, and the forms of agreement (Kenig, 2011).

The study was conducted in two different phases to include a pilot study to qualify the questions or items used for the final study. A factor analysis process was also used to assure there would be a "measure of the degree of generalizability between each variable or item and each factor is calculated and referred to as a factor loading" (Gorsuch, 1993). Factor loadings identify quantitative relationships between the factors to be measured. Therefore, the researcher looked for is how far from zero the factor load exists within the data. If the factor loading is large, then greater generalizability can be assumed about the specific factor. In this study, conceptual factor analysis was used to determine the item factor loadings across the five variables of economics, environment, politics, project, and technology. Because of this process, five of the factors could be reduced or measured to similar or different categories (Gorsuch, 1993). Most importantly, factor analysis as used in this study provided a statistical grounding for the development of the evidence-based model. A factor analysis table was built to show how factors were aligned based on the component headings for the two variables of DBB and DB.

To assure the quality of the survey instrument the pilot test was used to fine tune the final questionnaire with thirty (30) potential participants and 93 items included in the survey questionnaire. The equations used to analyze the factor patterns between and within the two variables included the following process:

$$X_{DBB} = w_{vDBB}F_{ec} + wv_{DBB}F_{en} + wv_{DBB}F_{po} + wv_{DBB}F_{pr} + wv_{DBB}F_{te} \quad \text{(Eq. 1)}$$
$$X_{DB} = w_{vDB}F_{ec} + wv_{DB}F_{en} + wv_{DB}F_{po} + wv_{DB}F_{pr} + wv_{DB}F_{te} \quad \text{(Eq. 2)}$$

Participants used in the study provided a total of thirty (30) participants. The participants were interviewed to determine their level of experience with the two project delivery methods to be tested based on their experience. Participants also provided comments and feedback to the researcher to assure the validity of the items to be incorporated within the survey.

After the data was received, combined, and synthesized it was cleaned and checked for any missing data. Cronbach's alpha was used to determine the internal consistency within the questionnaire The coefficient alpha of .84 suggested that the survey instruments were internally consistent. The mean and alpha was measured for each delivery method (DBB M = 3.17, α = .67 and DB M = 3.46, α = .79) are shown in Table 3.

Table 3

Construct Reliability

Construct	**M**	**α**
Econometrics	3.22	.85
Environment	3.20	.87
Politics	3.34	.53
Project	3.29	.56
Technology	3.65	.59

As shown above the constructs for econometrics and environment proved to be internally consistent using the alpha measure. Since the goal of the study is to compare the differences and similarities between DBB and DB across economic, environmental, political, project and technological project variables. The study also aimed to explain the complexity of project delivery between the two delivery methods. Through the pilot test the researcher used a factor analysis process to determine the strength of the itemized questions starting with 93 questions then further reducing the questions to a 48-item analysis. Questions were created using literature on the risks of the two project delivery methods. Results of the pilot test are shown in Table 4.

Table 4.

48 Item Analyses

	Constructs									
Variables	Economics		Environment		Politics		Projects		Technology	
	α	M	α	M	α	M	α	M	α	M
DBB	.70	55.4	.93	29.8	.87	13.2	.78	29.8	.67	18.8
DB	.89	61.6	.83	36.2	.77	11.2	.66	34.8	.82	19.8

α = alpha, M = mean, DBB = Design-bid-build, DB = Design-build

The alpha measures and means for each of the delivery methods and constructs were used to reduce the number of questions for the survey. While all alpha levels were above the .64 minimum, the mean for the political questions were the lowest of the groups of within the constructs for the project delivery methods. Using this rationale, the researcher removed the political questions from the survey instrument because means were the lowest comparatively (DBB M = 13.2, DB M = 11.2). This reduced the number of questions to 42 questions for the final survey instrument.

Analysis and Results

To compare the two project delivery methods, a two-way analysis of variance (ANOVA) was conducted. A two-way ANOVA was selected because the study is comparing the independent variable of the project delivery methods design-bid-build and design-build on the four dependent variables of econometrics, environment, project, and technology (Huck, 2004). These comparisons would be used to populate the evidence-based model for comparative analysis. More specifically, the ANOVA searched for differences between the independent variables of project delivery across the four main constructs of economics, environment, project, and technology. The two-way ANOVA analysis structure reveals statistically significant main affects between each of the project delivery methods and constructs. The researcher was looking for differences between the means of the project delivery method and the construct.

A sample of 108 participants took part in this study and were selected based on their current employment position, number of years in the construction industry, duration of projects they participated on the delivery methods of DBB and DB. Screening indicated the data was normally distributed and met the assumptions for parametric tests. A strong Cronbach's alpha of .88 was achieved with an inter-item mean of $M = 3.34$. Table 4 shows the reliability analysis for each project delivery variable. There was a strong Cronbach's alpha for DBB ($N = 54$, $\alpha = 0.85$, $M = 3.31$) and for DB ($N = 54$, $\alpha = 0.90$, $M = 3.45$). The alphas for these two variables provide an assessment of the internal consistency and reliability of the multiple item scales for the two questionnaires.

Most of the participants in this study were project managers, upper-level management, or held other types of positions, such as consultants, architects, or higher-level management with multiple responsibilities with in-depth knowledge of project delivery methods (Field Supervision, 28%, Project Managers, 36.1%, Upper-Level Management, 19.4%, Design Professionals, 41.7%). It was found that most of the participants had more experience working with the DBB project delivery method. The descriptive statistics help show the level of experience and knowledge the participants had with the tow project delivery methods within the four constructs of economy, environment, project, and technology.
The experienced participants provided findings on econometrics, environment, project, and technology helped expose some of the potential risk factors within the major constructs of this study. Additional data was collected to identify differences within the continuum of the project delivery method. The researcher was interested in explaining where along the project continuum differences existed between the project delivery methods. Further analysis of the data determined if differences existed on cost and schedule items associated with the two project delivery variables.

To observe where differences existed between the two delivery methods an ANOVA was conducted. Questions were grouped based on their syntax structure. For example, the questions were sorted by language, if they stated where or what differences existed. These where or what questions were purposely designed to identify the differences within the project delivery continuum. This defined the locations of risk in the project delivery method. A multivariate normality showed no sign of non-normality. Skewness statistics were within the acceptable limits for the conduct of an ANOVA.

The ANOVA was also used to answer the questions associated with the differences between DBB and DB project delivery methods to identify where and what differences exist along the project continuum. Between the two project delivery methods there were significant differences that existed with the beginning stages of the project in the feasibility, planning, design, and construction stages. Additional significant differences were associated with the idea how costs were identified between the two delivery methods. Data suggested there were significant differences between the two delivery methods on whether the costs are known during the design, expectations for change orders, and expectations of schedule change during construction. There were significant differences associated with known costs at the design phase, expectations for change orders, and expectations for schedule change. Table 5 shows the statistics for where the differences exist between the project delivery methods associated with their risk factors.

Table 5

ANOVA Source Table for Where Differences Exist Between Project Delivery Methods

Variable	Source	df	SS	MS	F	P
Technology	Between groups	1	21.33	21.33	17.57	<.001
	Within groups	106	128.74	1.22		
Quality During Design	Between groups	1	13.37	13.37	10.27	.002
	Within groups	106	138.04	1.30		
Inspection During Planning	Between groups	1	14.08	14.08	8.99	.003
	Within groups	106	166.02	1.57		
Inspection During Feasibility	Between groups	1	6.26	6.26	4.35	.039
	Within groups	106	152.41	1.44		
Environmental During Design	Between groups	1	24.08	24.08	15.00	<.001
	Within groups	106	170.24	1.61		
Quality During Feasibility	Between	1	32.23	32.23	24.29	<.001
	Within	106	140.69	1.33		

The data above suggests that the significant differences exist within the beginning phases of the project. Among the four main constructs, the project construct provided the most significant information on project risk with the two different delivery methods. Risk factors that tended to have a stronger significance included the factor of inspection during planning, which had a greater mean ($M = 2.80$) in the DB project delivery method compared to the mean in DBB ($M = 2.31$) $F(1, 106) = 8.99$, $p = .003$. More importantly with the project construct, there was also a strong significance with the collocation of stake holders where the mean for DB ($M = 4.09$) compared to DBB's mean ($M = 3.50$) $F(1, 106) = 7.97$, $p < .006$. Finally, under the technology construct, the significance of a participant's ability in selecting the most modern construction means and methods to improve the overall project functionality was greater with the DB delivery method ($M = 4.04$) than DBB ($M = 3.15$) $F(1, 106) = 17.57$, $p < .001$.

Conclusion and Discussion

Why would someone want to study the risk components associated with project delivery from an industry perspective? What this study attempted to do was to reach into the professional knowledge base to categorize and evaluate risk and develop a model to explain the differences that exist from a practical user perspective, industry professionals. If we look back into the history of project delivery, the differences with project delivery exist because project delivery systems were created to segment the work and streamline the construction process to meet needs of the time. The mechanisms that control this process exist in the cost, schedule, and quality factors that can be observed within each project delivery methods. Differences exist because project delivery is a complex network of econometric, environment, project, and technology factors. In each of these constructs there are cost, schedule, and quality factors that could be shared within each of the constructs. It is then up to the construction manager to make sense of all the items as a function of econometrics, environment, project, and technology as they relate to the project. Many of these cost, schedule, and quality factors associated with these factors may not be fully understood at the point of delivering the project because projects are unique and complex in their structure. But they should be exposed to improve communication and discussion from a risk management perspective.

This research adds to the body of knowledge in construction management and evidence-based research related to construction to suggest a different model or even a different way of thinking when reviewing projects to include the constructs of econometrics, environment, project, and technology. The research did expose the fact that characteristics associated the management team, project team, specifications and drawings, design, and experience were significant factors between the two different delivery methods. The study also seemed to expose that additional information may be needed to understand the political nature of the construction project delivery methods. These studies would be interesting to identify how politics between the two different delivery methods would affect the efficiency of the project delivery processes within the teams that deliver the project.

Evidence-based project delivery is important because it applies experiential knowledge commonly found in the field of construction to manage and analyze risk associated with project delivery. The research exposes a different organizational structure to the common risks that are found within the project delivery methods based on the perceptions from experienced industry professionals. This organizational structure is important to be able to analyze the data from which important management decisions are made within these two different delivery methods.

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