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The Impact of Project Delivery Methods on Dispute Occurrence in Public Highway Projects

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THE IMPACT OF PROJECT DELIVERY METHODS ON DISPUTE OCCURANCE IN PUBLIC HIGHWAY PROJECTS

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CHAPTER I: INTRODUCTION

1.1 Introduction

The construction industry is a complex and competitive industry in which different participants with different expertise, talents, and levels of knowledge work together to achieve their objectives and complete a project. The field of construction project management is directly related to the project success, and deals with how the success criteria are evaluated. Construction project performance is usually determined by meeting three criteria: time, cost, and quality. The success criteria vary from project to project since there are different types of projects with different people (Kylindri, Blanas, Henriksen, & Stoyan, 2010). In the construction industry, especially in traditional contract environment, the client and construction professionals often develop a win-lose mentality in operating projects. This condition often creates conflicts in communication and cooperation, leading to litigations between clients and professionals (Chen, 2010). In this situation, conflicts arise and become inevitable. Conflicts in projects will cause an adversarial environment which result to disputes. Hence, if conflicts are not well managed and resolved in a timely manner, they quickly turn into disputes, which prevent the successful completion of the construction project, in terms of cost and time, and increasing the potential for poor project performance and failures.

Conflicts on construction projects are rather the norm than the expectation. About 30% of construction projects have severe disputes, and one of the four construction projects has a claim in which it can be turned into disputes which is very expensive in terms of dollar value and time consuming. The transactional costs of disputes and claims resolution are estimated between $4 to $12 billion per year (Federal Facilities Council , 2007). Such costs include lawyers and witnesses fees, employees' salaries and overhead (who divert from productive profit-making work to litigation activities) as well as construction process inefficiencies and delays. Ultimately, the costs of hostile relationships remove any opportunity for profits from repeat business (Cakmak & Cakmak, 2014). Hence, to reduce these issues, the construction industry is moving towards more collaborative approaches. Collaboration can improve efficiency in construction projects and it is proven to reduce conflicts in construction project (Chen, 2010).

On the other hand, every owner who is responsible for the implementation of a construction project must make an early and important decision regarding the procurement method used on his or her projects. To this end, many methods have been developed to set up the contractual relationships and level of involvement between parties, which are called project delivery methods (PDM). According to Associated General Contractors (AGC), a PDM is "the comprehensive process of assigning the contractual responsibilities for designing and constructing a project" (Halpin & Senior, 2013). According to another definition, a PDM is a system designed to achieve the satisfactory completion of a construction project from conception to occupancy. A PDM may employ any one or more contracting formats to achieve the delivery (CMAA, 2012). In the other words, alternative PDMs could be thought as a method that creates a collaborative environment that aims to less adversarial relationships between construction parties leading to less disputes, which is an important consideration prior to starting a project, since it significantly affects budget, quality, design, project scheduling, risk sharing, payment method, and relationships.

1.2 Statement of the problem

Conflicts could majorly be attributed to the lack of understanding and common grounds between parties that has been largely reinforced by the traditional procurement method that ultimately selects contractors based on low bid and fosters adversarial relationships, with each party focusing on its own interests. This situation has led the construction industry to find alternative PDMs that hypothetically create a collaborative environment that links the individual parties' success with the overall project success. It has also been conceived that selecting the most appropriate project delivery and management method is a key to reduce disputes on a project. *However, to date, there has been no empirical research conducted to investigate this conception, especially as related to highway projects.* Therefore, the aim of this research is to investigate empirically the impact of project delivery method on dispute occurrence on highway projects from the owner's perspective. In essence, *has the use of more collaborative forms of PDMs resulted in less dispute occurrence?*

1.3 Significance of this study

This research empirically addresses the impact of PDM on severity and frequency of the disputes, which based on such a choice can result in. As a result, this study is discussing whether the PDM selection can affect the type and severity of the disputes in projects or not. This study can help those people who are making a decision to select an appropriate PDM to facilitate the decision process. For example, the pros and cons of each PDM will be explained to see whether any type of PDM can reduce or share the risk between parties in order to reduce the disputes or to see other positive and negative impacts on outputs. Since disputes lead to project delays and failure to meet the contract specifications and building standards (Tolson, 2013), hence, significant amount of time, effort, funds, and energy can be saved and allocated towards providing more benefits to the project users.

Many research studies, scholars, and practitioners started investigating the alternative PDMs' impact on cost, schedule, quality, party's relationship, and sustainability; however, there is still limited research to investigate empirically the impact of the PDM on the dispute resolution process and the choice to resolve disputes outside of the litigation and arbitration. Due to the lack of understanding regarding the theory and practice of how PDMs, contract types, procurement, and team behavior can affect disputes, the aim of this study is to conduct a close investigation on how PDMs' choice has affected disputes in construction contracts. Accordingly, this research attempts to answer the following questions: "*What is the effect of PDM selection on the frequency and severity of dispute occurrence in highway construction projects from the owner's perspective?"*

1.4 Research methodology

To answer the research question and achieve the objective of this study, the researchers designed a web-based survey questionnaire. The respondents answered series of questions on the procurement process and dispute occurrence of three recently completed highway projects with preferably different PDMs employed (such as design-build, construction manager/ general contractor (CM/GC), and design-bid-build). The survey target respondents were experts in 50 state departments of transportation who have been involved in the procurement/innovative contract delivery process.

CHAPTER II: REVIEW OF LITERATURE

2.1 Introduction

There are numerous construction projects taking place around the world and contracts are signed for each project. The client parties shall quote their objective in the contract and expect parties to abide by their agreement for mutual benefits (Dhanushkdi, 2012). In the construction process, there are so many parties involved like suppliers, buyers and builders. The relationships among these parties are maintained by forming a contract. A contract is a legal agreement made between two or more parties for a delivery of certain services in return for money or any other value. The main function of a contract is to (Dhanushkdi, 2012):

1) To specify the work to be done.

2) The amount to be paid.

3) To assign the responsibilities to the parties to finish the work.

4) Decide who takes charge for unexpected events if they occur.

The success of a construction project may depend on how well factors such as procurement methods, payment types, organizational and contractual policies, change orders mechanism, scheduling, budget, level of design, level of the trust in organization and etc. are going to be managed and addressed.

Therefore, this chapter will be discussing about following categories as relevant to the study.

The first section of this chapter will be a history of the studies conducted in PDMs; and the second section will be discussing about the disputes and disputes resolution methods used in construction industry, and give the readers a comprehensive understanding of different types of resolving methods for disputes along with the advantages and disadvantages of each method.

2.2 Project delivery methods

With the many causes of disputes and continuously emerging conception that alternative project delivery methods reflect the collaborative-based approach of project delivery compared to traditional project delivery, which is viewed as more adversarial, the question becomes whether the alternative PDMs used in public highway projects have been able to reduce dispute occurrence on highway projects. According to AGC (Associate General Contractors) a Project Delivery Method is “the comprehensive process of assigning the contractual responsibilities for designing and constructing a project” (Halpin & Senior, 2013). This method is an important consideration prior to starting of a project, since it has a significant impact on budget, quality, design, risk, and project scheduling. The most common PDMs used in the construction industry are design-bid-build (DBB), design-build (DB), and Construction Manager/General Contractor (CM/GC).

DBB, the traditional form of PDM, typically involves three sequential phases: design, bid, and construction. The owner hires an engineer to design the project and develop the plans and specifications. The project is then put up for a competitive bid when a contractor is procured, who builds the project. Project award is usually based on the lowest responsive bid with fixed price contracts (Figure 1). DBB are challenged by creating adversarial relationships among project participants and lacking of contractor’s input during design which eventually leads to potential change orders. In case of DB PDM, the owner hires one entity to serve as both the engineer and the contractor (Figure 2). This set-up allows contractor's input during design, single point of responsibility for construction and design, and fast-track delivery. In addition, construction can start before the design completion and thus saves time. The owner can also use the contractor's expertise during the design phase of the project and the architect/engineer's expertise during the construction phase. In recent years, the use of DB has considerably increased in the U.S, and it is making this delivery method one of the most significant methods in design and construction today. Research has found that the DB is more effective in large and complex projects (Konchar & Sanvido, 1998). The last most popular method discussed in this paper is CM/GC which is a PDM that implicates a commitment by the CM for construction performance to hand over the project through a defined schedule and price either a fixed price or Guaranteed Maximum Price (GMP). This method features a cohesive three-party team of owner, separate architect-designer, and the construction firm serving as construction manager (Figure 3). The advantages of this method is that the selection is usually qualification-based and the owner can save time and money by reducing change orders that can result in disputes.

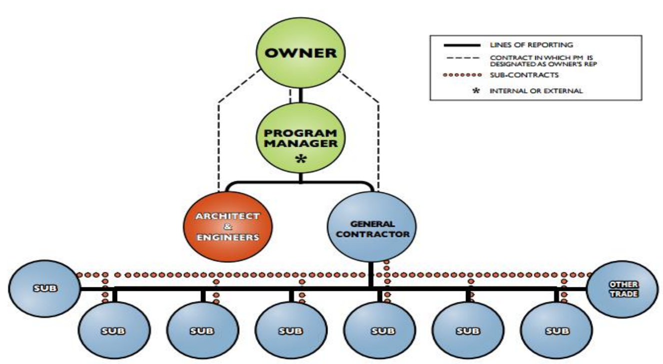

Figure 1: Design-bid- build diagram (Brookwood, 2015)

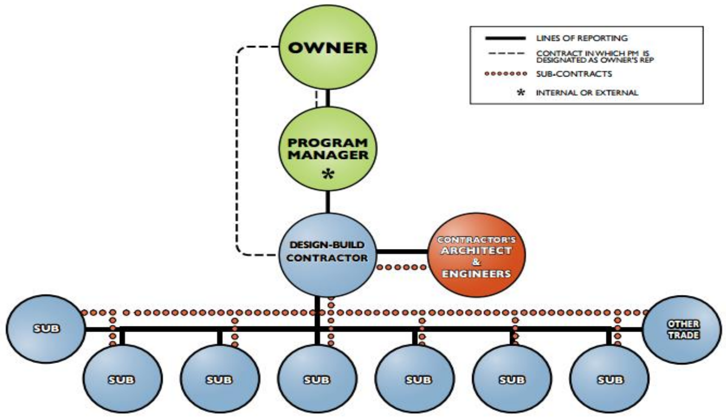

Figure 2: Design- build diagram (Brookwood, 2015)

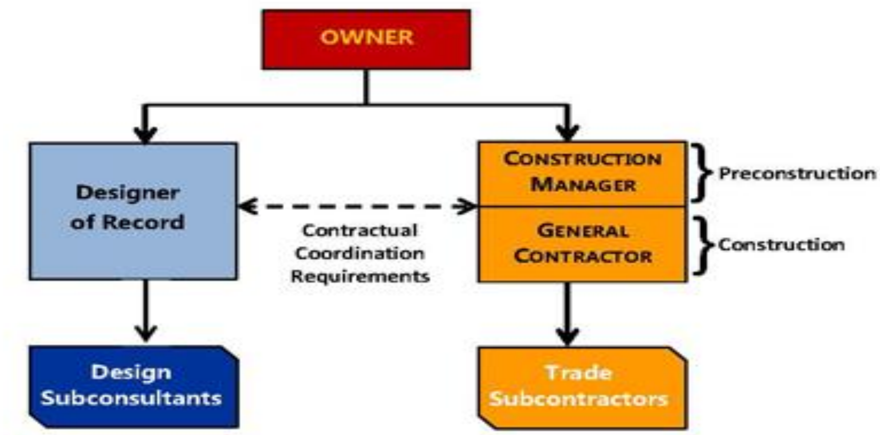

Figure 3: Construction management/ general contractor diagram (FHWA, 2015)

The Integrated Project Delivery Method (IPDM) is also a new method that has been developed to share more risk between parties to be fair. IPDM is conceptually based on a collaborative arrangement of the major project stakeholders early in the process, implemented in an environment of "best-for-project thinking" and shared risk and reward. This collaboration of stakeholders works to define project issues at the outset, helping to identify conflicts, establish performance criteria, minimize waste, increase efficiency, and maximize the scope achieved for limited project budgets. The ultimate goal is to create a project environment that produces a positive outcome for all stakeholders. Although not exclusive to the IPDM, multi-party agreements can include incentive clauses based on the idea of shared savings among the project team (The American Institute of Architects & The Associated General Contractors of America, 2011).

Most studies conducted, in public highway projects, focused on comparing various PDMs in terms of their performance (cost, schedule, sustainability, and quality). Warne (2005) conducted a performance assessment of DB contracting for highway projects in terms of schedule, cost, quality, and owner satisfaction, by gathering information on 21 DB highway projects ranging in size from $83 million to $1.3 billion. Shrestha et al. (2012) also focused on highway projects investigating project performance metrics of 130 DB large highway projects in Texas. Results, in both studies, showed that the selected projects were built faster using DB than they would have been with DBB (Shrestha , O'Connor , & Gibson , 2012). As DB is more widely being implemented, studies whether on the national or state level are continuously being conducted to evaluate DB projects' performance (FHWA and FDOT). In January 2006, FHWA published the results of a comprehensive national study conducted to evaluate DB contracting effectiveness, from different states that were taking the lead on DB implementation.

Research studies were also conducted to evaluate quality such as the Arizona DB projects quality study, quality qualifications assessment in DB solicitation documents and a synthesis of how quality is handled in DB projects (Gransberg & Molenaar, 2004). In another study, Minchin et al. (2013) compared time and cost performance of 60 projects from Florida DOT (FDOT) and found that DBB projects outperform DB projects in terms of cost (Minchin, Li, Issa, & Vargas, 2013). As can be seen, most research discussed earlier have considered cost, time, and quality but there hasn't been any major work that directly addresses the relationship between PDM used and disputes occurrence, especially as related to highway projects.

There are few research studies that have been published about project performance in terms of disputes occurrence and the PDMs employed. Of the few that were conducted, the Federal Facilities Council (2007) compiled a report of presentations given by speakers who are experts in resolving construction disputes. Reports in Pentagon renovation project have shown, the projects that transferring risk to the contractor and they have a low-bid process are more apt to have such disagreement. Contracts should portray realistic risk assignment to parties rather than convey the bargaining powers of the parties. In addition, unfair risk allocation, the report addressed disputes' causes that are attributable to the contracting/bidding strategy such as low bid process, poorly developed contracts, and lack of project management procedures (FFC). Another interesting observation by Independent Project Analysis's study conducted on projects of diverse types was that, in contrary to the perception that fewer claims are anticipated in shared risk contracts, no difference was seen between claims' frequency on shared risk versus contractor-allocated risk contracts. This was attributed to inappropriate risk allocation strategies. The study also looked at DRM choice showing that arbitration encouraged inflated claim values while other forms such as DRBs and mediation did not affect claim frequency (FFC, 2007).

Two other studies, one in Malaysia and the other in UK reported that alternative PDMs reduced disputes frequency (Ndekugri & Turner, 1994). Mante et al. (2012) conducted a preliminary study on dispute resolution by analyzing DRM provisions in standard contract forms showing that regardless of the PDM, the same dispute resolution provisions were used (Mante, Ndekugri , Ankrah , & Hammond , 2012). The paper also reinforced our literature review that the amount of research done related to PDM and dispute occurrence is limited.

2.3 Disputes and disputes resolution methods

The topics of disputes and claims have been extensively researched in construction, mostly focus on identifying the causes of disputes/claims and the different forms of dispute resolution methods used. The substantial issue springs from when the world is experiencing economic troubles and money is tight, disputes often arise, because construction project participants are not willing/able to compromise. Disputes over actual or implied variations and scope of work, are the most common concerns during construction of a project. Hereby, when conflicts do not get resolved in a timely manner, they become very expensive – in terms of finances, personnel, time, and opportunity costs. The visible expenses (e.g., attorneys, expert witnesses, the dispute resolution process itself) alone are significant. The less visible costs (e.g., company resources assigned to the dispute, lost business opportunities) and the intangible costs (e.g., damage to business relationships, potential value lost due to inefficient dispute resolution) are also considerable, although difficult or impossible to quantify. It is estimated that construction litigation expenditures in the United States have increased at an average rate of 10 percent per year during 1988-1998, and now total nearly $5 billion annually (Michel, 1998).

As a result, many of these disputes ultimately must be resolved in the legal system (Klinger, 2009). There are many causes of disputes on construction projects. The most problematic issues in construction projects are as follows: first, are plans and specifications/scope of work, in this situation when there is no detail and clear information attached or when it is ambiguous, owner, contractor, designer, and engineering interpret different description, and ultimately it could result in a conflict. Second, are shop drawings and submittals that they are not fully followed, and then they cause delays, either in the timeliness of the contractor/subcontractor submitting shop drawings and submittals or in the design professionals responding back in a timely fashion. Third, Change orders/extra or out-of-scope work in which disputes start due to whether or not the contractor/ subcontractor is entitled to extra time. The forth is differing site condition, with two different approaches. The common approach is that the owner has the duty to disclose information, even if the owner does not have any knowledge about the construction phases (Klinger, 2009).

Acharya and Lee (2006) also identified almost similar issues which confirms the effects of the above issues in construction disputes. They have determined six critical conflicts in construction industry: site conditions, local people obstruction, errors and omissions in design, double meaning in specifications, excessive quantity of works, and difference in change order evaluation (Acharya, Lee , & Im, 2006). Sigitas and Tomas (2013) hypothesize that the true cause of construction-related conflicts is unsuccessful communication among the construction project participants (Neuendorf, 2002). Cheng. S and Peng. K (2013) in their research showed that disputes are an epidemic factor of the construction industry with inadequate contract documents (contract incompleteness) and behavioral factors being the notable sources of disputes.

In the transportation sector, Mahany. H and Grigg. N (2014) used data collected from Colorado Department of Transportation projects to test the causes of potential claims; of the 780 projects reported that were completed between 1997 to 2012, 213 claims in 62 projects showed that delays were the main reason for claims and were even more significant compared to change orders. This study also showed that the project with fixed completion date are more prone to claims than the flexible completion dates (Mehany & Grigg, 2014). On the other side, Ibbs. W and Chen. C showed that the primary reason of claims are changes that stem from schedule delays and cost overruns. To avoid changes, they developed a tool named Proactive Project Change - Prediction Tool based on empirical formulation which attempts to improve change management and accordingly project performance (Ibbs & Chen , 2015). With late deliverables being an inevitable factor resulting in claims as well, the Construction Industry Institute (CII), in collaboration with Construction User Roundtable and the Commissioned Research Team investigated the different types of late deliverables that affect cost, quality, safety, and organizational performance, in an attempt to help reduce disputes (Barry & Leite, 2015).

Thus, all of the research studies done showed that disputes frequently stop the project's progress, causing major conflicts that affect project performance (Schieg, 2008). If not properly managed, disputes may lead to delays in projects, lower team spirit, increase project costs, and damage business relationships (Chan & Suen, 2005).

In addition to the court route –litigation- of dispute resolution, the construction industry has been on the innovative edge of dispute resolution with many forms of Alternative DRMs (ADRMs) such as negotiation, dispute review boards (DRBs), arbitration. According to the American bar, ADRMs are increasingly used in the construction industry in lieu of or as a step preceding litigation, as they can handle disputes quicker and are relatively inexpensive. Gad et al (2015) mentioned that these alternative DRMs could be binding to assure parties that they will not have to resort to outside litigation to settle disputes (Gad, Momoh, Esmaeili, & Gransberg, 2015).

The most common form of ADRM is negotiation which is usually the first step towards any dispute resolution. There are many advantages to negotiation as it is private and confidential, quick and inexpensive with parties having full control of the process (Safinia , 2014). As for mediation, Texas Civil Practice and remedies code 154.023 defines mediation as "a forum in which an impartial person, the mediator, facilitates communication between parties to promote reconciliation, settlement, or understanding among them." In a simple language, mediators are neutral third parties, but a good listener for both parties to find an overall solution by suggesting and urging two parties to solve their issues. It can occur as early in the process as the parties are able to organize mediation and identify a mutually agreeable mediator (Klinger, 2009).

One of the increasingly used forms of DRM in the highway public sector are DRBs. DRBs involves three neutral experts who visit the site periodically and monitor progress and potential problems that might lead to disputes. Once a dispute occurs, it is brought to the board who conducts an informal hearing and issues an advisory opinion that could be either binding or non-binding. DRB cost is far less than using arbitration or litigation. Finally, arbitration is a non-judicial form of dispute resolution. Its main advantage emerges from the fact that construction disputes usually require the third party to be well-versed not only in legal issues but also in technical and industrial matters (Yates & Smith, 2007). Though similar to litigation, it has many advantages over litigation, as it is less formal alternative, less expensive and time consuming, private, and not subject to the public disclosure. Other than the previously discussed ADRs, litigation comes as the traditional method employed in courts; it is based on law; a doctrine that requires a court follow-up (County Court, High Court or Technology and Construction Court), in which parties are represented by attorneys (Safinia , 2014).

Litigation in construction is known for its many disadvantages, as it is the most adversarial of all DRMs, it is a long expensive process, and public. In the public sector, there are often requirements that contractors must go through a ‘Government Claims Procedure’ by filing a government claim and going through an administrative hearing procedure before they can proceed to arbitrate or litigate their claims (Klinger, 2009).

Another dispute resolution method is known as adjudication. Adjudication is a legal process in which judges investigate the evidences and the proofs, and make a decision to determine the rights and obligation between the parties involved.

Figure 4 shows a comparison between the Dispute Resolution Methods in terms of the parties involved, control level of the parties, decision enforceability, privacy, and cost.

DRMs / Pt. of comparison	Litigation	Arbitration	Mediation	Adjudication	DAB	Expert Determination
Parties involved in the decision	Judges and courts	Arbitrators	Mediators and Parties	Adjudicator	Panel of experts	An expert
Control level of the parties	None	Minor	Full	Average	Average	Minor
Decision enforceability	Final and binding	Final and binding	Non-binding	Binding, if stated in contract	Non-binding	Final and binding
Privacy	Public	Confidential	Confidential	Confidential	Confidential	Confidential
Relative duration	Very long	Long	Short	Short-set	Short	Short
Relative cost	Very expensive	Expensive	Less expensive	Average	Average	Not expensive
Key points	Technical knowledge compromised	Technical knowledge not compromised	Solution may not follow contract	Decision can be appealed	DAB knowledgeable of project	Preferred in complex technical issues

Figure 4: Comparison of different DRMs (Ghada G. M., 2012)

2.4 Point of departure

Since disputes in the projects are problematic in construction industry, therefore, it has been decided to conduct a research in construction industry through department of transportation agencies in which many complex and huge projects have been completed. Therefore, the objective of the study is to investigate several projects contracted in DOTs and find an answer for the research question which is “whether there is a relationship between PDM selection and disputes in construction in highway projects. In the other words, the research team decided to conduct this study to recommend a better way or more effective type of PDM if possible, so that have more satisfactory outputs. In addition, can this study help what other factors cab be influenced by PDM selection? By finding answers for the above questions, the study can be helpful for the future projects in DOTs or it can be useful for other researchers to research more in the other related areas and factors or they may find other alternative project delivery methods that they may have better results.

CHAPTER III: RESEARCH METHODOLOGY

3.1 Introduction

This chapter provides an overview of the different types of research methods, and then describes the research methodology adapted to conduct this study. The chapter also explains each stage of the research design, outlines, distribution, data collection and analysis mechanism applied in addition to the validation techniques utilized. This section presents the restatement of the problem, research design, and general characteristic of the study population. Hence, before discussing the methodology of the study, the research topic, objectives, and questions are restated. To this end, this research discusses the impact of PDM selection on disputes occurrence on highway projects in the United States. In this regard, following question is going to be answered:

What is the effect of PDM selection on the frequency and severity of dispute occurrence in highway construction projects?

3.2 Research methods

Common research methodologies used for studies are interviews, observations, questionnaires, documentary analysis, surveys, and experiments. All these types of the methodologies are trying to answer the research question, and finally to achieve the objectives. Each has its specific problems of validity and reliability, and limits to generalizability. There are three types of research methods used in this study including quantitative research, qualitative research and mixed method which will be explaining in the following sections.

3.2.1 Quantitative research

Quantitative research is used to quantify the problem by way of generating numerical data or data that can be transformed into useable statistics. It is used to quantify attitudes, opinions, behaviors, and other defined variables – and generalize results from a larger sample population. Quantitative research uses measurable data to formulate facts and uncover patterns in research (Wyse, 2011).Using this type of research method is preferred when researching a fact about a concept or a question by collecting factual evidence and studying the relationships between those facts (Naoum, 2007).

3.2.2 Qualitative research

Qualitative research focuses on attitudes, behaviors, meanings and experiences through getting an in-depth opinion from the respondents. Since it involves a deeper look at people's opinions, it involves less number of people compared to the quantitative method and is subjective in nature (Dawson, 2002). Additionally, it seeks to understand a given research problem or topic from the perspectives of the local population. Qualitative research is especially effective in obtaining culturally specific information about the values, opinions, behaviors, and social contexts of particular populations.

Since construction engineering research involves studying aspects that involve people, it becomes not surprising to inherent social science research methodologies (Abowitz & Toole, 2010). For example, the team behavior and the spirit of a team-working environment in construction project are parts of this study that needs to be addressed through the qualitative method.

3.2.3 Mixed method

Mixed methods originally evolve to examine different approaches of collecting data (Creswell, 2009), and is defined as a research approach or methodology that (Johnson, Onwuegbuzie, & Turner, 2007):

1- Focuses on research questions that call for real-life contextual understandings, multi-level perspectives, and cultural influences

2- Employs rigorous quantitative research assessing magnitude and frequency of constructs and rigorous qualitative research exploring the meaning and understanding of constructs

3- Utilizes multiple methods (e.g., intervention trials and in-depth interviews)

4- Intentionally integrates or combines these methods to draw on the strengths of each

5- Frames the investigation within philosophical and theoretical positions

3.3 Survey

In order to get the results of this study, the research team prepared a survey in following steps. The survey was used, because it was easy to distribute it in terms of time and cost. Also, collecting the data digitally, made it easier for research team to analyze the data quicker and more effective. In addition, online survey include quantitative and qualitative questions to rank and evaluate the important parameters.

3.3.1 Survey target population

The target population were state DOT’s employees involved in the procurement and project delivery process. Questionnaire requested participants to respond series of questions of three completed highway projects with preferably different PDMs employed (such as DBB, DB, and CM/GC), and based on the literature review, the survey encompassed questions on factors reported by previous studies to affect disputes/claims such as partnering, type of relationship (first or repeat), agreement types, trust, team behavior and communication. As it has been investigated, the relationship between all mentioned factors can affect dispute occurrence. Therefore, in this study the research team as trying to see all sensitive factors and finally achieve any results related to those critical factors.

These potential respondents were contacted by phone to request participation in the survey. As a reminder, the DOT is the owner of the highway projects, and the responses are on behalf of the owners' perspective of the projects. Of these 112 potential respondents, 77 were willing and have had the required expertise to respond to the survey. Prior to survey publishing, it was pilot tested on 10 respondents familiar with this topic who asked to provide comments and feedback on the survey questions and any issues that need to be revised. The survey mode utilized three waves: (1) an email with an explanatory cover letter and a link to a web-survey was sent, (2) two weeks later, a follow-up email was sent to non-respondents, emphasizing the importance of their participation and requesting their response, and (3) finally, non-respondents contacted by phone.

3.3.2 Survey design and distribution

To design and arrange the content of this survey, researchers have collaborated to design a comprehensive survey to include the substantial items in the survey, and it was reviewed and corrected frequently by academics and graduate students. The distribution of survey was online, and spread out through email.

In general, the survey is divided into six main sections. The first section asks for general information such as the respondents' demographic information, number of years' experience, the state of the residency, and the particular section of DOT. The second and third sections seek information about the level of complexity, type of PDM, and involvement level in the recent three projects. The fourth section asks questions on team procurement and contract's types. Fifth section focuses on change orders and disputes frequency and severity. The last section focuses on team behaviour and communication, and the partnering process characteristics. All of the mentioned sections can influence on the results of the disputes. This research focuses on the disputes occurrence and PDM results.

CHAPTER IV: FINDINGS

The inherence of this study is to analyze the collected data and explore the answer of the question of this research which is “the relationship between the PDMs used in highway projects and its impact on disputes occurrence”. In this chapter, we will be reporting the data to present some recommendations based on the collected information. The study has been created to analyze each question inferentially and descriptively, and eventually see the conclusion based on the results gained from the experts of DOTs.

Statistical methods are conducted to compare, result, describe, discuss and finally make decision based on some definitions, terms and calculations. It is a way of analyzing data in a more objective manner. Statistical analysis could be done descriptively and inferentially. Descriptive analysis is the simple way of analyzing data based on the basic features. They provide simple summaries about the sample and the measures. We use inferential statistics to try to infer the sample data in order to understand what the population might think or, we use inferential statistics to make judgments of the probability that an observed difference between groups is a dependable one or one that might have happened by chance in this study. Thus, we use inferential statistics to make inferences from our data to more general conditions (William, 2006).

4.1 General data information and demographics

The data gathered came from 50 States in the United State with the collaboration of Department of Transportation. According to the demographic data, more than 83 % of participants are experienced more than 10 years. Each respondent was asked to provide up to three recent highway projects. On average, half of states responded at least one project in last 3 years; however, several states provided more than one project.

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Figure 5: States involved in the research

Figure 5 indicates the number of the projects collected from various states. Out of 25 responsive states showed in Figure 5, the research team was able to collect data on 62 projects, which has been showed in the United States map.

Figure 6 shows that the majority of the experts work in the construction group, alternative project delivery section, design group, and contract-procurement group respectively. In addition, there are few projects collected from other departments including operation and material group.

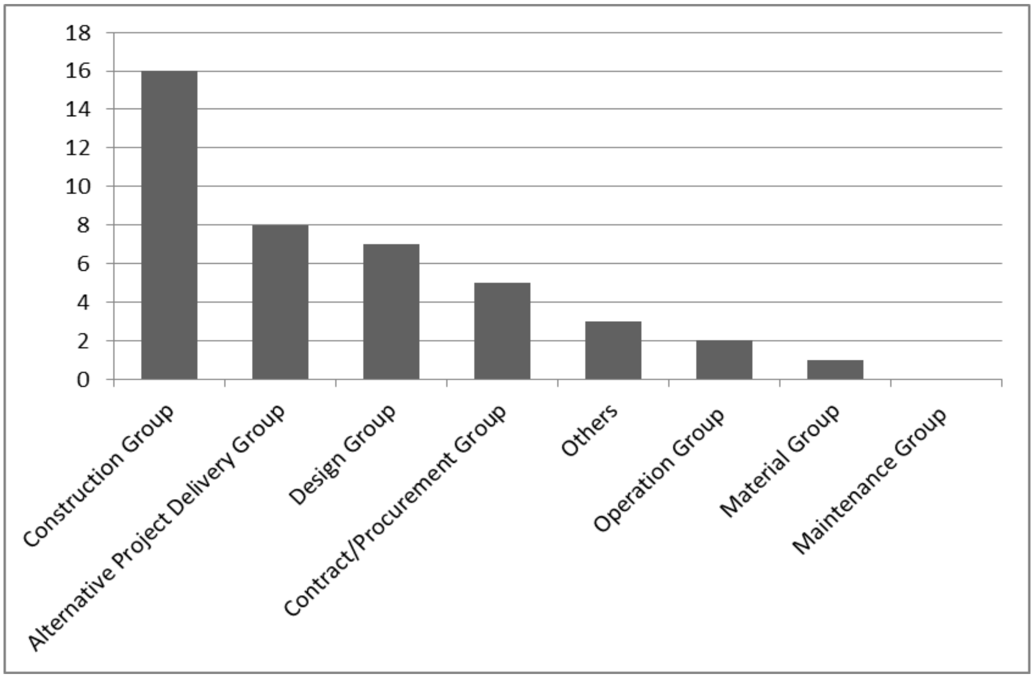

Figure 6: Various department participation in the research

According to the data, the majority of the projects are built using Design Bid Build method, and the CM/GC with the lowest is the least number of projects used. There are 32 projects in DBB, 23 projects in DB and only 7 projects in CM/GC (Figure 7).

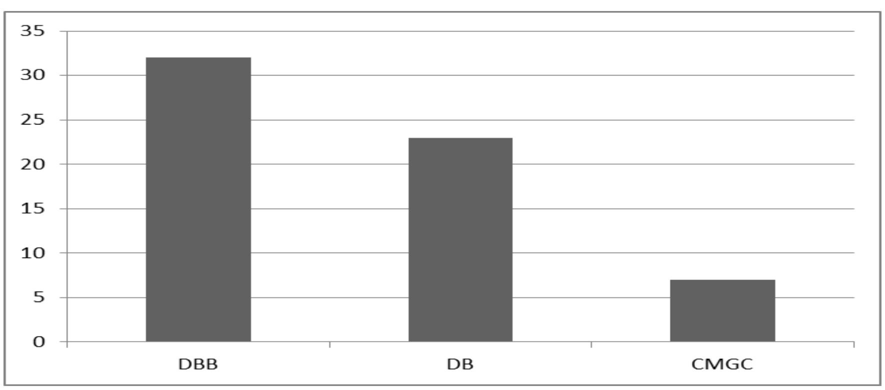

Figure 7: Number of PDM used in DOTs contracts

Projects results show that 96% of the project contract values are more than $500,000.00 and only 4% of the project values are less than that, something between

$100,000.00 and $300,000.00. Moreover, it is estimated that around 50% of the project durations are more than 2 years, 30% are between 1 and 2 years; and 8% are less than 6 months in highway projects (Figure 8).

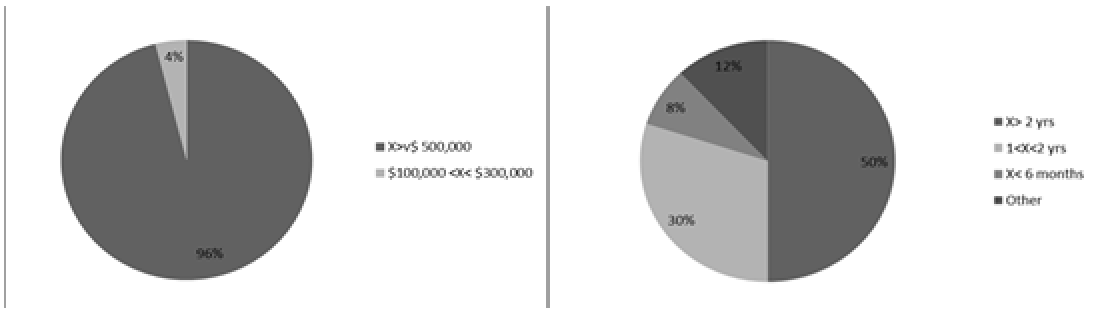

Figure 8: Project budgets and durations

Table 1 shows the number of the projects with the participant involvement, including Architect/Designer (A/D), Construction Manager/ General Contractor (CM/GC), Construction Manager At Risk (CMAR), Design Builder (DB) and Sub-contractor, during the different phases. These phases include Pre-design Phase (PD), Concept (CO), Schematic Design (SD), Design Development phase (DD), Construction Document (CD), or during the bidding process (full design). As the Table 1 shows, architects and designers are involved more in first stages including the pre-design phase and concept phase which is almost 30 % of the completed project. Design builders are involved in schematic design while general contractor collaborates in last phase, which is the bidding process. Subcontractor’s function is also similar to general contractor role with participating in the very last stage in bidding process.

Table 1: Participant involvement in different phases

Phases	pre- Design	Concept	Schematic design	Development design	Construction documents	BID
A/D	***9***	***13***	7	1	2	1
CMGC	2	1	2	1	2	***4***
CMAR	1	2	2	1	2	*0*
DB	N/A	5	*11*	1	1	3
Sub	N/A	N/A	3	2	N/A	**0**

In addition, the level of design and construction complexity are measured during this study based on a ranking bar between 1 to 6, with 1 being least complex to 6 being most complex (Table 2). This measurement of the complexity has been based on the experience of the respondents. Table 2 shows the design and construction complexity in all type of PDMs completed by DOTs. Out of 62 projects measured in the following table, the average design and construction complexity for each project delivery method has been evaluated. The complexity of each delivery method is important, because if the complexity is higher, the possibility to have a higher dispute will increase due to having unclear and complex drawing and specs.

Table 2: Design and construction complexity

Factors/ PDM	DBB	DB	CM/GC
Design complexity	4.13	4.15	4.45
Construction complexity	4.36	4.47	4.65

Table 3 determines the proposals solicited from project participants. It shows that the most of the architect/designer were chosen through three methods; prequalification, one stage, and two stages process. The solicitation from construction manager and general contractor were open - bid which is a normal practice to select the contractor in public projects with 28 projects. In addition, the selection of design builders was based on the two stages process with 17 projects shown in the Table 3.

Table 3: Participant solicitation methods

Participant	Open- Bid	Prequalification	One stage	Two stages
Architect/Designer	2	***13***	***15***	***12***
GC	***28***	4	0	3
CM	0	0	3	2
Design Builder	1	2	1	***17***

Moreover, according to the observations (Table 4), the research implies the most payment used for each project in the bold and italicized numbers. The most used payments are lump sum, unit price, and cost plus fixed fee. For architects are cost plus fixed fees, for general contractors and subcontractors are unit price, and for design builders are lump sum. This means, in general, the most method used for GC and subcontractor which utilized in DBB is unit price and for DB is lump sum method which can be related to the PDM used in the contract.

Table 4: Payment methods in each PDM

Participant Payment type	**Architect**	**General contractor**	**Construction manager**	**Design build**	**Subcontractor**
Lump sum	16%	3%	-	***34%***	6.6%
Unit price	5%	***52%***	5%	3%	***30%***
Cost plus fixed fee	***45%***	-	3%	-	-
Cost plus % fee	5%	-	-	-	-

In addition, the Table 5 reports the type of the relationship between owner and stakeholder in different project delivery methods, and demonstrates that the most of the projects were selected through the repetitive relationships. This is very interesting observation, because even though DBB is usually based on the lowest bid price. In this sample study, 100% of the contractors in DBB method have been selected to build the highway projects for the second/repetitive times. This means all contractors were familiar with the type, nature, risk and the structure of the project which are critical factors in construction contracting. Not only in DBB, but also in DB and CM seem to follow the same trend.

Table 5: The owner and builders relationship

PDMs	**DBB**	**DB**	**CM**
First Time	0%	35%	24%
Repeat	***100%***	***65%***	***76%***

In addition, the study points out that almost all of the projects conducted have had a claim more or less. The frequency of the claims in all project delivery methods is identified less than 65% meaning that the frequency of occurring a claim is low. The study also presents excellent information that there is a very low percentage issues in the projects which means that whenever a claim arose, the claim was resolved quickly without third part involvement, and only few projects needed a third party such as mediator to resolve the issue. Out of 62 projects in all PDMs, only 11 projects are recorded that needed a third party to resolve the dispute and 51 projects did not need a third party and the problem was solved in very early stages without taking the case to the court. The study shows that equally only 22% of projects in the DBB and DB method had escalated to a form of DRM and 78% of the projects did not encounter any escalation to turn into to a dispute which is a good trend in highway projects. In CM method, 28.5% of the projects had a dispute needed a third party, and 71.5% did not have such an issue during construction.

Table 6 demonstrates how the participants were able to solve their issues through the following (ADRMs) when conflicts arose during project. ADRMs used in the different PDMs include negotiation, mediation, arbitration, dispute review board, adjudication, and litigation.

The table obviously shows that the contractor and the owner were able to resolve a claim mostly through a dispute review board, negotiation, and litigation respectively. In addition, in several projects, mediation, arbitration, and adjudication have been used as an Alternative Dispute Resolution.

Table 6: DRMs used in project

PDMs/DRMs	DBB	DB	CM
Negotiation	8	11	2
Mediation	5	1	0
Arbitration	2	2	1
Dispute Review Board	13	8	4
Adjudication	2	0	0
Litigation	7	3	0

By now, the research points out some descriptive analysis and general concepts about the nature of this research. This study not only focuses on the descriptive analysis, but also it tends to discuss more in depth. In order to do so, the researcher also uses inferential statistic to test some hypotheses on the descriptive data presented specifically as related to dispute occurrence. The inferential statistic is trying to comply the answer of the question of this research precisely, and restate “is there any relationship between the PDM selection and disputes or claims occurrence in highway projects”? Hence, to find the answer, the study uses one-way ANOVA test to statistically compare the mean of three PDMs used (DBB, DB, CM/GC) in this study.

Also, a two- sample t test used for the comparison between DBB and DB as well as a comparison between DBB and the other two alternative PDMs (DB and CM/GC).

Again, remember that the objective of this study is to discover whether there is a relationship between PDMs selection and dispute occurrence in highway projects. To do so, the research points out the most critical factors in each PDM that may affect disputes directly or indirectly. Table 7 shows a descriptive analysis of those factors that are going to be discussed in the rest of the research. As mentioned, since a PDM is a complex of the cost, design, schedule and design and construction process, we are trying to have a comprehensive analysis of all influenced items in PDMs. Parameters such as cost claim severity, time claim severity, time and cost claim frequency, overall satisfaction, design satisfaction, construction satisfaction, cost growth and schedule growth. Cost and time claim severity means those claims that were related to the cost and the time during project. Time and cost claim frequency refers to the frequency of the time and cost claims relevant to the project. For the time and cost claim frequency and severity the ranking bars were between 1 to 6; from least to most. If there number is close to 1, the severity and frequency were at least, and if gets close to the 6, the severity and frequency were high. Overall satisfaction, design and construction satisfaction were related to the satisfaction of the projects; and show how satisfied were the projects with a ranking form 1 to 6. 1 is the less satisfaction and 6 is a very satisfied result. The cost growth is the actual cost and the percentage change compared to the original cost with a ranking from 1 to 6. 1 is the less difference and 6 is a bigger gap between the actual cost and the original cost. Table 7 shows the descriptive analysis of the parameters including mean, median standard deviation.

Table 7: Descriptive analysis of parameters

Parameter	no	Mean	SE Mean	SD	Median
Cost claim severity DBB	28	2.60	0.33	1.77	2.00
Cost claim severity DB	22	2.31	0.25	1.17	2.00
Cost claim severity CM	7	2.14	0.40	1.06	2.00
Time claim severity DBB	28	2.35	0.31	1.66	2.00
Time claim severity DB	2	2.31	0.22	1.04	2.00
Time claim severity CM	6	2.16	0.47	1.16	2.00
Time & cost claim freq DBB	28	2.42	0.30	1.62	2.00
Time & cost claim freq DB	22	2.09	0.20	0.97	2.00
Time & cost claim freq CM	7	2.14	0.40	1.06	2.00
Overall satisfaction DBB	31	4.61	0.18	1.02	5.00
Overall satisfaction DB	23	4.82	0.18	0.88	5.00
Overall satisfaction CM	6	5.00	0.15	0.15	5.00
Design satisfaction DBB	26	4.07	0.19	1.01	4.00
Design satisfaction DB	22	4.22	0.20	0.97	4.00
Design satisfaction CM	7	4.42	0.61	1.61	5.00
Construction satisfaction DBB	28	4.28	0.19	1.01	4.00
Construction satisfaction DB	22	4.54	0.15	0.73	4.00
Construction satisfaction CM	7	4.14	0.26	0.69	5.00
Cost growth DBB	22	2.27	0.24	1.16	2.00
Cost growth DB	20	1.60	0.16	0.75	1.00
Cost growth CM	6	2.66	0.66	1.63	2.50
Schedule growth DBB	20	2.45	0.28	1.27	2.50
Schedule growth DB	18	1.88	0.22	0.96	1.50
Schedule growth CM	5	2.20	0.80	1.87	1.00

4.2 Normality Test

Before carrying out the inferential statistic, the data distribution is tested for each potential effective parameter for normality. The normality tests are conducted in using normality test with Anderson Darling method in 95% Confidence Intervals. According to the obtained p-value, the data are mostly not distributed normally. For some of the CM/GC parameters, the normality test observation was not strong enough to reject the null hypothesis or accept the alternate hypothesis.

The followings are the hypotheses that are considered:

H_0: The data are distributed normally for each parameter.

H_1: The data are not distributed normally.

Table 8 is a summary of normality test for each parameter that may have an impact on the dispute resolution. “X” sign means that the determined hypotheses are rejected and the check mark “√” is showing that the determined hypotheses are accepted.

Table 8: Normality test results

Parameter	P-value	H_0	H_1
Cost claim severity DBB	P < 0.005	X	√
Cost claim severity DB	P < 0.005	X	√
Cost claim severity CM/GC	P= 0.249	√	X
Time claim severity DBB	P < 0.005	X	√
Time claim severity DB	P < 0.005	X	√
Time claim severity CM/GC	P= 0.428	√	X
Time & cost claim frequency DBB	P < 0.005	X	√
Time & cost claim frequency DB	P < 0.005	X	√
Time & cost claim frequency CM/GC	P= 0.249	√	X
Overall successful of DBB	P < 0.005	X	√
Overall successful of the DB	P < 0.005	X	√
Overall successful of CM/GC	P= 0.122	√	X
Design satisfaction of DBB	P < 0.005	X	√
Design satisfaction of DB	P < 0.005	X	√
Design satisfaction of CM/GC	P= 0.008	√	X
Construction satisfaction DBB	P < 0.005	X	√
Construction satisfaction DB	P < 0.005	X	√
Construction satisfaction CM/GC	P= 0.050	√	X
Cost growth DBB	P= 0.011	√	X
Cost growth DB	P < 0.005	X	√
Cost growth CM/GC	P= 0.573	√	X
Schedule growth DBB	P= 0.014	√	X
Schedule growth DB	P < 0.005	X	√
Schedule growth CM/GC	P= 0.052	√	X

As the above table shows (Table 8), the p-value shows that whether the data are normally distributed or not. In the other words, “the p-value is the probability that the null hypothesis is true”. Table 9 shows how the p-value is measured.

Table 9: The p-value definition

P > 0.10	No evidence against the null hypothesis
0.05 < P < 0.10	Weak evidence against the null hypothesis in favor of the alternative
0.01 < P < 0.05	Moderate evidence against the null hypothesis in favor of the alternative
0.001< P < 0.01	Strong evidence against the null hypothesis in favor of the alternative
P < 0.001	Very strong evidence against the null hypothesis in favor of alternative

4.3 One-way ANOVA Test among DBB, DB, and CM parameters

After discussing the type of the distribution, the one way ANOVA has been used to test whether there is a significant difference among the DBB, DB, AND CM/GC means.

There are three required assumption to do the ANOVA test:

1- Data are independent.

2- Distribution of each group is normal.

3- The variances are the same for all groups.

However, the data are not mostly distributed normally, but as Riffenburgh stated that “Analysis of variances is fairly robust against these assumptions, so we need not be stringent about them, but the data should not be extremely far off” (Riffenburgh, 2006).

Therefore, the one-way ANOVA test has been considered to determine whether there is any significant differences between the means of critical parameters of PDMs. Followings are the ANOVA test for each parameter.

4.3.1 One-way ANOVA: Cost claim severity DBB, DB and CM/GC

A one-way ANOVA test has been conducted among DBB, DB and CM/GC to find if there is any significant variance among means for the cost claim severity.

H_0: There is no significant difference between means of cost claim severity of DBB, DB and CM/GC.

H_1: The means of the cost claim severity of the DBB, DB and CM/GC are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 2.60, SD= 1.77, N=28, f= 0.39, p=0.68$) over the DB ($M = 2.31, SD= 1.17, N=22, f= 0.39, p=0.68$) and *CM/GC* ($M = 2.14, SD= 1.06, N=7, f= 0.39, p=0.68$). The p= 0.68 is greater than α = 0.05 and there is no adequate evidence to reject the null hypothesis.

4.3.2 One-way ANOVA: Time claim severity DBB, DB and CM/GC

A one-way ANOVA test has been conducted among DBB, DB and CM/GC to find if there is any significant difference among means for the time claim severity.

H_0: There is no significant difference between means of time claim severity of DBB, DB and CM/GC.

H_1: The means of the time claim severity of the DBB, DB and CM/GC are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 2.35, SD= 1.66, N=26, f=0.05, p= 0.95$) over the DB ($M = 2.31, SD= 1.04, N=22, f=0.05, p= 0.95$) and *CM/GC* ($M = 2.16, SD= 1.16, N=6 , f=0.05, p= 0.95$).

The p= 0.95 is greater than $\alpha = 0.05$ and there is no adequate evidence to reject the null hypothesis.

4.3.3 One-way ANOVA: Time and cost claim frequency DBB, DB and CM/GC

A one-way ANOVA test has been conducted among DBB, DB and CM/GC to find if there is any significant difference among means for the time and cost claim frequency.

H_0: There is no significant difference between means of time and cost claim frequency of DBB, DB and CM/GC.

H_1: The means of the time and cost claim frequency of the DBB, DB and CM/GC are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 2.42$, $SD = 1.62$, $N=28$, $f = 0.42$, $p=0.65$) over the DB ($M = 2.09$, $SD = 0.97$, $N=22$, $f = 0.42$, $p=0.65$) *and CM/GC* ($M = 2.14$, $SD = 1.06$, $N=7$, $f = 0.42$, $p=0.65$). The p=0.65 is greater than $\alpha = 0.05$ and there is no adequate evidence to reject the null hypothesis.

4.3.4 One-way ANOVA: Overall successful of DBB, DB and CM/GC

A one-way ANOVA test has been conducted among DBB, DB and CM/GC to find if there is any significant difference among means for the overall successful of the project.

H_0: There is no significant difference between means of overall satisfaction of DBB, DB and CM/GC.

H_1: The means of the overall successful of the DBB, DB and CM/GC are significantly different.

Results indicate that there is no significant differences in the α *= 0.05* for DBB (*M = 4.61, SD= 1.02, N=31, f = 0.54, p=0.58)* over the DB (*M = 4.82, SD= 0.88, N=23, f = 0.54, p=0.58) and CM/GC* (*M = 5.00, SD= 1.26, N=6, f = 0.54, p=0.58).* The p= 0.58 is greater than α = 0.05 and there is no adequate evidence to reject the null hypothesis.

4.3.5 One-way ANOVA: Design satisfaction of DBB, DB and CM/GC

A one-way ANOVA test has been conducted among DBB, DB and CM/GC to find if there is any significant difference among means for the design satisfaction.

H_0: There is no significant difference between means of design satisfaction of DBB, DB and CM/GC.

H_1: The means of the design satisfaction of the DBB, DB and CM/GC are significantly different.

Results indicate that there is no significant differences in the α *= 0.05* for DBB (*M = 4.07, SD= 1.01, N=26, f = 0.32, p=0.72)* over the DB (*M = 4.22, SD= 0.97, N=22, f = 0.32, p=0.72) and CM/GC* (*M = 4.42, SD= 1.61, N=7, f = 0.32, p=0.72).* The p=0.72is greater than α = 0.05 and there is no adequate evidence to reject the null hypothesis.

4.3.6 One-way ANOVA: Constriction satisfaction of DBB, DB and CM

A one-way ANOVA test has been conducted among DBB, DB and CM/GC to find if there is any significant difference among means for the construction satisfaction.

H_0: There is no significant difference between means of construction satisfaction of DBB, DB and CM/GC.

H_1: The means of the construction satisfaction of the DBB, DB and CM/GC are significantly different.

The means of construction satisfaction in all project delivery methods in the $\alpha = 0.05$ indicate that there is no significant differences between DBB (*M = 4.28, SD= 1.01, N=28, f = 2.71, p=0.07)* over the DB (*M = 4.54, SD= 0.73, N=22, f = 2.71, p=0.07) and CM/GC* (*M = 5.14, SD= 0.69, N=7, f = 2.71, p=0.07).* The p=0.07 is greater than α = 0.05 and there is no adequate evidence to reject the null hypothesis. However, since the *p= 0.07* is close to the α = 0.05, thus, this factor may be considered as a sensitive parameter.

4.3.7 One-way ANOVA: Cost growth of DBB, DB and CM/GC

A one-way ANOVA test has been conducted among DBB, DB and CM/GC to find if there is any significant difference among means for the cost growth.

H_0: There is no significant difference between means of cost growth of DBB, DB and CM/GC.

H_1: The means of the cost growth of the DBB, DB and CM/GC are significantly different.

As the analysis shows, the means of construction satisfaction in all project delivery methods in the $\alpha = 0.05$ indicate that there is a significant differences between DBB (*M = 2.27, SD= 1.16, N=22, f = 3.18, p=0.05)* over the DB (*M = 1.60, SD= 0.75, N=20, f = 3.18, p=0.05) and CM/GC* (*M = 2.66, SD= 1.63, N=6, f = 3.18, p=0.05).* Since the p = 0.05, therefore the null hypothesis is fairly rejected. As it is seen, the mean of the cost growth of DBB is 2.27 and DB is 1.60. This mean, the DB performance was better and the cost growth was less than 15 % of the project, while the DBB cost growth was more and approximately close to 25% which is a huge dollar value for highway projects.

4.3.8 One-way ANOVA: Schedule growth of DBB, DB and CM/GC

A one-way ANOVA test has been conducted among DBB, DB and CM/GC to find if there is any significant difference among means for the schedule growth.

H_0: There is no significant difference between means of schedule growth of DBB, DB and CM/GC.

H_1: The means of the schedule growth of the DBB, DB and CM/GC are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB (*M = 2.45, SD= 1.26, N=20, f = 1.00, p=0.37)* over the DB (*M = 1.88, SD= 0.97, N=18, f = 1.00, p=0.37) and CM/GC* (*M = 2.20, SD= 1.78, N=5, f = 1.00, p=0.37).* As the p = 0.37, and it is greater than 0.05, therefore there is no significant different between the means of all PDMs.

Table 10 shows the one-way ANOVA test summary report for all parameters stated above. This table expresses a summary of the results and shows that only cost growth with the p= 0.05 is the most significant parameter among the other parameters. As it was stated before, the cost growth in DBB is higher than the DB method. Therefore, it seems that the performance of the DB has been better in comparison to the DBB method. Again, the null hypothesis and alternative hypothesis for all the parameters are stated as follows:

H_0: There is no significant difference between means of parameters of DBB, DB and CM/GC.

H_1: The means of the parameters of the DBB, DB and CM/GC are significantly different.

Table 10: The One-way ANOVA Test for Critical Parameters in PDMs

Parameter	PDM	Mean	SD	n	f-value	p-value
Cost claim severity	DBB	2.60	1.77	28		
	DB	2.31	1.17	22		
	CM/GC	2.14	1.06	7		
Total					0.39	0.68
Time claim severity	DBB	2.35	1.66	26		
	DB	2.31	1.04	22		
	CM/GC	2.16	1.16	6		
Total					0.05	0.95
Time & claim freq	DBB	2.42	1.62	28		
	DB	2.09	0.97	22		
	CM/GC	2.14	1.06	7		
Total					0.42	0.65
Overall success	DBB	4.61	1.02	31		
	DB	4.82	0.88	23		
	CM/GC	5	1.26	6		
Total					0.54	0.58
Design satisfaction	DBB	4.07	1.01	26		
	DB	4.22	0.97	22		
	CM/GC	4.42	1.61	7		
Total					0.32	0.72
Construction satisfaction	DBB	4.28	1.01	28		
	DB	4.54	0.73	22		
	CM/GC	5.14	0.69	7		
Total					2.71	0.07
Cost growth	DBB	2.27	1.16	22		
	DB	1.60	0.75	20		
	CM/GC	2.66	1.63	6		
Total					3.18	*0.05**
Schedule growth	DBB	2.45	1.26	20		
	DB	1.88	0.97	18		
	CM/GC	2.20	1.78	5		
Total					1.00	0.37

4.4 Two sample T-test, the difference between means of DBB and DB parameters

In addition to the ANOVA test conducted for all project delivery methods, the t-test is used to find the differences between two major groups of the contract types. Since, the majority of the project contracts were either DBB or DB delivery methods, therefore, the research team chose to compare whether there is a significant difference between the mean of DBB and DB delivery methods or not. T is simply calculated difference represented in units of standard error. The t test also developed under the following assumption (Riffenburgh, 2006):

1- The sample observations are independent.

2- They are normally distributed.

3- They have equal standard deviation.

The Riffenburg stated, "these assumptions usually are not satisfied exactly, however the robustness of the test allows it to be valid if the assumption are roughly approximated." Since the data are not too far off, therefore, with the assumption of the normal distribution, the t test has been conducted to obtain a fair result. The greater the magnitude of T (it can be either positive or negative), the greater the evidence against the null hypothesis that there is no significant difference. In addition, if the p value is less than 0.05, then the mean difference will be significantly different.

4.4.1 Two sample T-test: Cost claim severity DBB and DB

A two sample t- test has been conducted between DBB and DB to find if there is any significant difference between means of cost claim severity of DBB and DB.

H_0*: There is no significant difference between means of cost claim severity DBB and DB.*

H_1: The means of the cost claim severity of the DBB and DB are significantly different.

Results indicate that there is no significant differences in the *α = 0.05* for DBB (*M = 2.61, SD= 1.77, N=28, t = 0.69, p=0.49)* over the DB (*M = 2.32, SD= 1.77, N=22, t= 0.69, p=0.49).* Since the *p=0.49* is greater than *α = 0.05,* it can be concluded that there is no difference between the means.

4.4.2 Two sample T-test: Time claim severity DBB and DB

A two sample t- test has been conducted between DBB and DB to find if there is any significant difference between means of time claim severity of DBB and DB.

H_0: There is no significant difference between means of time claim severity DBB and DB.

H_1: The means of the time claim severity of the DBB and DB are significantly different.

Results indicate that there is no significant differences in the *α = 0.05* for DBB (*M = 2.36, SD= 1.66, N=28, t = 0.10, p=0.92)* over the DB (*M = 2.32, SD= 1.04, N=22, t= 0.1, p=0.92).* Since the *p=0.92* is greater than *α = 0.05,* it can be concluded that there is no difference between the means.

4.4.3. Two sample T-test: Time & cost claim frequency DBB and DB

A two sample t- test has been conducted between DBB and DB to find if there is any significant difference between means of time and cost claim frequency of DBB and DB.

H_0: There is no significant difference between means of time and claim frequency DBB and DB.

H_1: The means of the time and cost claim frequency of the DBB and DB are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 2.43$, $SD = 1.62$, $N=28$, $t = 0.91$, $p=0.36$) over the DB ($M = 2.09$, $SD = 0.97$, $N=22$, $t = 0.91$, $p=0.36$). Since the $p=0.36$ is greater than $\alpha = 0.05$, it can be concluded that there is no difference between the means.

4.4.4 Two sample T-test: Overall success of the DBB and DB

A two sample t- test has been conducted between DBB and DB to find if there is any significant difference between means of overall success of DBB and DB.

H_0: There is no significant difference between means of overall success of DBB and DB.

H_1: The means of the overall success of the DBB and DB are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 4.61$, $SD = 1.02$, $N=31$, $t = -0.82$, $p=0.41$) over the DB ($M = 4.82$, $SD = 0.88$, $N=23$, $t = -0.82$, $p=0.41$). Since the $p=0.41$ is greater than $\alpha = 0.05$, it can be concluded that there is no difference between the means.

4.4.5 Two sample T-test: Design satisfaction DBB and DB*

A two sample t- test has been conducted between DBB and DB to find if there is any significant difference between means of design satisfaction of DBB and DB.

H_0: There is no significant difference between means of design satisfaction of DBB and DB.

H_1: The means of the design satisfaction of the DBB and DB are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 4.08$, $SD= 1.02$, $N=26$, $t = -6.91$, $p=0.73$) over the DB ($M = 4.22$, $SD= 0.97$, $N=22$, $t = -6.91$, $p=0.73$). Since the $p=0.73$ is greater than $\alpha = 0.05$, therefore it can be concluded that there is no a significant difference between the means.

4.4.6 Two sample T-test: Construction satisfaction DBB and DB

A two sample t- test has been conducted between DBB and DB to find if there is any significant difference between means of construction satisfaction of DBB and DB.

H_0: There is no significant difference between means of construction satisfaction of DBB and DB.

H_1: The means of the construction satisfaction of the DBB and DB are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 4.29$, $SD= 1.01$, $N=28$, $t = -1.05$, $p=0.30$) over the DB ($M = 4.54$, $SD= 0.73$, $N=22$, $t = -1.05$, $p=0.30$). Since the $p=0.30$ is greater than $\alpha = 0.05$, it can be concluded that there is no significant difference between the means.

4.4.7 Two sample T-test: Cost growth DBB and DB*

A two sample t- test has been conducted between DBB and DB to find if there is any significant difference between means of cost growth of DBB and DB.

H_0: There is no significant difference between means of cost growth of DBB and DB.

H_1: The means of the cost growth of the DBB and DB are significantly different.

Results indicate that there is a significant differences in the $\alpha = 0.05$ for DBB ($M = 2.27$, $SD= 1.16$, $N=22$, $t = 2.24$, $p=0.03$) over the DB ($M = 1.60$, $SD= 0.75$, $N=22$, $t = 2.24$, $p=0.03$). Since the $p=0.03$ is smaller than $\alpha = 0.05$, therefore, it can be concluded that there is a significant difference between the means. Hence, the null hypothesis is rejected in favor of alternative hypothesis.

4.4.8 Two sample T-test: Schedule growth DBB and DB

A two sample t- test has been conducted between DBB and DB to find if there is any significant difference between means of schedule growth of DBB and DB.

H_0: There is no significant difference between means of schedule growth of DBB and DB.

H_1: The means of the schedule growth of the DBB and DB are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 2.45$, $SD= 1.28$, $N=20$, $t = 1.54$, $p=0.13$) over the DB ($M = 1.88$, $SD= 0.96$, *N=18, t = 1.54, p=0.13).* Since the *p=0.13* is greater than *α = 0.05,* it can be concluded that there is no difference between the means.

Table 11 is a summary report of the test between DBB and DB parameters.

Again, the null hypothesis and alternative hypothesis for all the parameters are stated as follows:

H_0: There is no significant difference between means of parameters of DBB, DB and CM/GC.

H_1: The means of the parameters of the DBB, DB and CM/GC are significantly different.

Table 11: The t-test for critical parameters compared DBB and DB means, p-value <0.05 is considered as a significant difference

Parameters	**PDMs**	**Mean**	**SD**	**n**	**df**	**t-value**	**p-value**
Cost Claim Severity	DBB	2.61	1.77	28			
	DB	2.32	1.77	22			
Total					46	0.69	0.49
Time Claim Severity	DBB	2.36	1.66	28			
	DB	2.32	1.04	22			
Total					45	0.1	0.92
Time & Cost Claim Freq	DBB	2.43	1.62	28			
	DB	2.09	0.97	22			
Total					45	0.91	0.36
Overall success	DBB	4.61	1.02	31			
	DB	4.82	0.88	23			
Total					50	-0.82	0.41
Design satisfaction	DBB	4.08	1.02	26			
	DB	2.09	0.97	22			
Total						-6.91	***0.00****
Construction satisfaction	DBB	4.29	1.01	28			
	DB	4.54	0.73	22			
Total					47	-1.05	0.30
Cost growth	DBB	2.27	1.16	22			
	DB	1.60	0.75	22			
Total					36	2.24	***0.03****
Schedule growth	DBB	2.45	1.28	20			
	DB	1.88	0.96	18			

Total	34	1.54	0.13

4.5 T test, the difference between means of DBB and APDMs parameters

Another test has been done through the t-test between the traditional delivery method DBB and other alternative project delivery methods (APDM) including DB and CM/GC. This test has been conducted to find if there is any significant difference between means.

4.5.1 Two-sample T-test: Cost claim severity DBB and APDMs

A two sample t- test has been conducted between DBB and APDMs to find if there is any significant difference between means of cost claim severity of DBB and APDMs.

H_0: There is no significant difference between means of cost claim severity DBB and APDMs.

H_1: The means of the cost claim severity of the DBB and APDMsare significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 2.61$, $SD= 1.77$, $N=28$, $t = 0.84$, $p=0.40$) over the APDMs ($M = 2.28$, $SD= 1.13$, $N=29$, $t= 0.84$, $p=0.40$). Since the $p=0.40$ is greater than $\alpha = 0.05$, it can be concluded that there is no difference between the means.

4.5.2 Two-sample T-test: Time claim severity DBB and APDMs

A two sample t- test has been conducted between DBB and APDMs to find if there is any significant difference between means of time claim severity of DBB and APDMs.

H_0: There is no significant difference between means of time claim severity DBB and APDMs.

H_1: The means of the time claim severity of the DBB and APDMsare significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 2.36$, $SD= 1.66$, $N=28$, $t = 0.19$, $p=0.84$) over the APDMs ($M = 2.29$, $SD= 1.05$, $N=28$, $t= 0.19$, $p=0.84$). Since the $p=0.84$ is greater than $\alpha = 0.05$, it can be concluded that there is no difference between the means.

4.5.3. Two-sample T-test: Time & cost claim frequency DBB and APDMs

A two sample t- test has been conducted between DBB and APDMs to find if there is any significant difference between means of time and cost claim severity of DBB and APDMs.

H_0: There is no significant difference between means of time and claim frequency DBB and APDMs.

H_1: The means of the time and cost claim frequency of the DBB and APDMsare significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 2.43$, $SD= 1.62$, $N=28$, $t = 0.91$, $p=0.36$) over the APDMs ($M = 2.10$, $SD= 0.97$, $N=29$, $t= 0.91$, $p=0.36$). Since the $p=0.36$ is greater than $\alpha = 0.05$, it can be concluded that there is no difference between the means.

4.5.4 Two-sample T-test: Overall success DBB and APDMs

A two sample t- test has been conducted between DBB and APDMs to find if there is any significant difference between means of overall success of DBB and APDMs.

H_0: There is no significant difference between means of overall success of DBB and APDMs.

H_1: The means of the overall success of the DBB and APDMs are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 4.61$, $SD = 1.02$, $N=31$, $t = -0.98$, $p=0.33$) over the APDMs ($M = 4.86$, $SD = 0.95$, $N=29$, $t = -0.98$, $p=0.33$). Since the $p=0.33$ is greater than $\alpha = 0.05$, it can be concluded that there is no difference between the means.

4.5.5 Two-sample T-test: Design satisfaction DBB and APDMs

A two sample t- test has been conducted between DBB and APDMs to find if there is any significant difference between means of design satisfaction of DBB and APDMs.

H_0: There is no significant difference between means of design satisfaction of DBB and APDMs

H_1: The means of the design satisfaction of the DBB and APDMs are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB ($M = 4.08$, $SD = 1.02$, $N=26$, $t = -0.69$, $p=0.49$) over the APDMs ($M = 4.28$, $SD = 1.13$, $N=29$, $t = -0.69$, $p=0.49$). Since the $p=0.49$ and it is greater than $\alpha = 0.05$, therefore, it can be concluded that there is no significant difference between the means.

4.5.6 Two-sample T-test: Construction satisfaction DBB and APDMs

A two sample t- test has been conducted between DBB and APDMs to find if there is any significant difference between means of construction satisfaction of DBB and APDMs.

H_0: There is no significant difference between means of construction satisfaction of DBB and APDMs.

H_1: The means of the construction satisfaction of the DBB and APDMs are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB (*M = 4.29, SD= 1.01, N=28, t = -1.70, p=0.09)* over the APDMs (*M = 4.69, SD= 0.76, N=29, t = -1.70, p=0.09).* Since the *p=0.09* is greater than $\alpha = 0.05$ it can be concluded that there is no significant difference between the means.

4.5.7 Two-sample T-test: Cost Growth DBB and APDMs

A two sample t- test has been conducted between DBB and APDMs to find if there is any significant difference between means of cost growth of DBB and APDMs.

H_0: There is no significant difference between means of cost growth of DBB and APDMs.

H_1: The means of the cost growth of the DBB and APDMs are significantly different.

Results indicate that there is no significant differences in the $\alpha = 0.05$ for DBB (*M = 2.27, SD= 1.16, N=22, t = 1.31, p=0.19)* over the APDMs (*M = 1.85, SD=*

1.08, N=26, t = 1.31, p=0.19). Since the *p=0.19* is greater than *ᾳ = 0.05,* therefore, it can be concluded that there is no significant difference between the means.

4.5.8 Two-sample T-test: Schedule growth DBB and APDMs

A two sample t- test has been conducted between DBB and APDMs to find if there is any significant difference between means of schedule growth of DBB and APDMs.

H_0: There is no significant difference between means of schedule growth of DBB and APDMs

H_1: The means of the schedule growth of the DBB and APDMs are significantly different.

Results indicate that there is no significant differences in the *ᾳ = 0.05* for DBB (*M = 2.45, SD= 1.28, N=20, t = 1.33, p=0.19)* over the APDMs (*M = 1.96, SD= 1.15, N=23, t = 1.33, p=0.19).* Since the *p=0.19* is greater than *ᾳ = 0.05,* it can be concluded that there is no difference between the means

Table 12 is a summary report of the test between DBB and APDMs parameters. Again, the null hypothesis and alternative hypothesis for all the parameters are stated as *follows:*

H_0: There is no significant difference between means of parameters of DBB, APDMs

H_1: The means of the parameters of the DBB and APDMs are significantly different.

Table 12: T-test for critical parameters compared DBB and APDMS Means

Parameters	PDMs	Mean	SD	n	df	t-value	p-value
Cost Claim Severity	DBB	2.61	1.77	28			
	APDMs	2.32	1.13	29			
Total					45	0.84	0.40
Time Claim Severity	DBB	2.36	1.66	28			
	APDMs	2.29	1.05	28			
Total					45	0.19	0.84
Time & Cost Claim Freq	DBB	2.43	1.62	28			
	APDMs	2.09	0.97	29			
Total					44	0.91	0.36
Overall success	DBB	4.61	1.02	31			
	APDMs	4.82	0.88	23			
Total					57	-0.82	0.41
Design satisfaction	DBB	4.08	1.02	26			
	APDMs	4.86	0.95	29			
Total					52	-0.98	0.33
Construction satisfaction	DBB	4.29	1.01	28			
	APDMs	4.5428	1.13	29			
					50	-0.69	0.49
Total							
Cost growth	DBB	2.27	1.16	22			
	APDMs	1.85	1.08	26			
Total					43	1.13	0.19
Schedule growth	DBB	2.45	1.28	20			
	APDMs	1.88	0.96	18			
Total					38	1.54	0.13

4.6 Conclusion

As it is stated earlier, the aim of this study was to answer the following question:

Whether there is a relationship between the PDM selection and dispute occurrence in highway project?

Table 13 is a conclusion of the results of the tests conducted. In general, it shows that how is the impact of PDM on critical parameters that may affect disputes in highway project.

Table 13: Summary report of results conducted

Parameters	ANOVA	T test DB & DBB	T test DBB & APDMs
Time claim severity	No difference	No difference	No difference
Cost claim severity	No difference	No difference	No difference
Time and cost claim frequency	No difference	No difference	No difference
Overall successful of the project	No difference	No difference	No difference
Design satisfaction	No difference	No difference	No difference
Construction satisfaction	No difference	No difference	No difference
Cost growth	Small differences	Significantly different	No difference
Schedule growth	No difference	No difference	No difference

4.7 Discussion

As it has been observed, the results mostly show that there is no significant difference between the most of the parameters evaluated in this study. Only significant difference is in the cost growth between the DBB and DB. As it can be interpreted, the mean of cost growth of DBB is higher than DB which is a negative point in DBB. Thus, DB has had a better performance in this parameter.

The results are showing interesting information to some extent. As the literature review shows, the DBB has been created more adversarial environment in the construction industry, because there is less collaboration between parties. In the DBB method, since the designers and contractor or sub- contractors or the other parties are separate, therefore, it has been said that the DBB has higher adversarial environment, while the DB method is known as a better method to perform construction since the designers and contractors are in the same company. As Konchar (1998) stated, the DB is more effective in large and complex projects, but the result in this study showed that there is no significant difference between the DBB and other alternative project delivery method. Also, the literature review said, the projects that transferring risk to the contractor and they have a low-bid process are more apt to have such disagreement. While this study inferentially claims that there are no significant differences between the three PDMs that have been reviewed here. Therefore, it can be said that there is no significant difference between DBB, DB and CMGC based on this study for the studied parameters, except in cost growth. In addition, the DB history shows that those projects that have use DB method have been built faster than the other methods. In this study, as we studied, the schedule growth remained the same for both DBB and DB.

The other researches may focus on the other parameters that can be significantly different. However, the only significant difference is the cost growth of DB which has had a better performance; while the cost growth is lower than DBB. The other parameters such as overall success of the project design and construction satisfaction, time and cost claim severity and frequency are evaluated and finally reached the same results for all studied PDMs.

The cost growth parameter has not been studied in literature review and we did not find any information in previous studies regarding that in PDMs which can be very helpful for the future researchers relevant to the PDM selection and DRMs.

Additionally, in the literature review, we studied that the conflicts on construction projects are rather the norm than the expectation; and was emphasized that about 30% of construction projects have severe disputes, and one of the four construction projects has a claim in which it can be turned into disputes. Also, in this study we reviewed that out of 62 projects, all of the project had disputes to some extent, but only 11 projects used litigation which is the sever form of dispute resolution in court.

In summary, as we discussed in literature review, the common belief is that the DBB has the highest adversarial environment which is not statistically different based on our results showed in this study.

CHAPETR V: CONCLUSIONS AND FUTURE RECCOMENDATIONS

5.1 Conclusions

Since the conflicts are common in construction industry and there are multiple parties including owner, architect, engineer, contractor, subcontractor, supplier etc., are involved with different interests, therefore, the disputes and claims make the construction industry to be a very risky industry, and claims are known as an inventible part of the construction in general. Hence, this study was conducted to empirically find a response for the important question of this study whether the PDM selection affects the dispute occurrence. There is a common belief that DBB projects have higher number of claims than DB project (Pishdad Bozorgi & J. de la , 2012). However, the result of this study demonstrates that the mean of the time and cost claim severity and frequency in all project delivery methods demonstrate that there are no significant differences between contract parameters. This thesis study statistically shows that that there is no significant differences between DBB, DB, CM/GC in terms of dispute occurrence, while the literature review said that DBB has been proved for higher adversarial environment.

There are several reasons that might have contributed to the results of this study based on the responses which could be explained through the other factors contributing to claim/dispute reduction incorporated in this survey. As it has been proved, in DBB projects, owners and contractors had a history of working together on all the projects studied. Hence, this might have additionally helped them to establish a collaborative team environment, regardless of the PDM selected. Moreover, as far as the study shows, more than 80 % of the project managers of all those projects were experienced for more than 10 years which can collaborate to have a better results. The study also shows that all projects had conflicts, but resolving the issue in the very early stages and using negotiation, mediation and dispute review board have helped parties to solve their issues quicker and cheaper, and eventually have a high overall satisfaction. Therefore, in fact, those factors can effectively collaborate and reduce the number of the claims and finally disputes in highway projects.

5.2 Limitations and future recommendations

However, the study shows that the selection of project delivery methods does not significantly affect dispute occurrence in highway projects, but also there have been some limitation in this study. For example, the number of the CM/GC projects was low, therefore, we could have had more number of the projects in CM/GC, but only 7 CM/GC projects out of 62 projects were collected. Due to this reason, sometimes some statistical tests were not robust against of the null hypothesis. Hence, it is needed to have numerous projects contracted under the CM/GC. In addition, other types of APDMs such as Construction Manager At Risk (CMAR), Public Private Partnership method (PPP), or Integrated Project Delivery Method (IPDM) and etc. can be studied to discover the new methods on partnering and collaboration. Another study can be conducted through a different owners or different people’s perspective as well; such as engineer, contractor, or other companies and find out if there is a significant difference among different PDMs and their impacts on disputes occurrence. This study can be done through those private entities that they have specifically practiced three methods including DBB, DB and CM in order to be comparable. In addition, the future studies can be focused on why the DBB with having a higher cost growth or an increased in actual cost still is in the same ranking with DB. As it has been observed, the cost growth can be a factor for increasing the unsatisfactory of the projects, but in this study, the overall success of the projects, the time and cost claim frequency and severity have the same results for all PDMs. In addition, for the farther studies, the researchers can find how impressive the collaboration between parties is. Whether having a more collaborative environment in specific phases can increase the satisfaction of a project or in the other words, whether it can help to reduce the disputes in construction projects.

APPENDICES

Appendix A: Bibliography

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Appendix B: Questionnaire

The Impact of Project Delivery Method on Dispute Occurrence in Public Highway Projects

Purpose: Bowling Green State University, University of Nebraska-Lincoln, and Iowa State University are conducting a survey to investigate the impact of (1) project delivery methods, (2) contract type, (3) procurement, and (4) team behavior on construction contract dispute. Please help us by completing the survey for ***3 highway projects*** you have completed. If possible, please select projects that employed different project delivery methods (such as design-build, CM/GC, and design-bid-build) that were completed ***during the last 5 years***. The questionnaire should take about 30 minutes to complete. Please return it within three weeks <04/29/15>

Confidentiality: The project information you provide will be kept in strict confidentiality, within a password protected database. Only the primary investigators and their research assistants will see and have access to your information. Your participation in this survey is completely voluntary. Please note that you may skip any question at any time that you feel uncomfortable answering. In the event of a publication or presentation based on the results of this study, no personal identifiable information will be shared.

Participation: Your decision to participate in this research is voluntary and you may withdraw at any time. There is no direct compensation; however, participants may request a copy of the final analysis. If you have any questions, complaints or concerns regarding this research, you may contact Samaneh Nasrollahi at Samanen@bgsu.edu or419-819-1565 and Dr. Ghada M. Gad at Gmgad@bgsu.edu or 419-372-5437.

Definitions

CM/GC or CM@Risk: Project delivery method in which a contract between an owner and a Construction manager who will be at risk for the final cost and time of construction is set up. In this agreement, the owner authorizes the construction manager to make input during project design. The contractor acts a GC and CM during the construction phase.

Design Bid Build: In this project delivery method, the owner first completes the design using either an in house or consultant designer, and upon the completion of the design, will solicit a contractor. Generally, the contractor is chosen on a basis of the lowest, responsive bid.

Design Build: A project delivery method where a single entity executes both engineering and construction services. The design builder may be a single integrated firm, a consortium, joint venture, etc. Thus, one entity assumes the primary responsibility for project design and construction.

Competency trust: This trust is based on the confidence gained from knowledge of an individual or an organization's cognitive abilities. The competence and the integrity of an individual or an organization are based on the knowledge of their past performance, reputation, organizational role, and financial status.

Organizational trust: This is trust that is developed through organizational policies and addresses formal and procedural arrangements.

Relational trust: Trust based on emotions that bonds people together thereby improving their performance and morale in a working relationship. These are trusts that enhance information exchange and team spirit, decrease defensiveness, unhealthy competitiveness, and eliminate frictions.

SECTION 1: PERSONAL INFORMATION

1. US state in which you are employed:

2. You are employed by what type of organization?

□ State Department of Transportation
□ Other public transportation agency; Name of Agency:
□ Federal Agency; Name of Agency:
□ Other; Please describe:

3. What group/section do you work in?

□ Design group/section
□ Construction group/section
□ Operations group/section
□ Maintenance group/section
□Alternative project delivery group/ section
□ Materials group/section
□ Contracts/procurement group/section
□ Other, please specify: ________________

4. Years of experience in construction industry:

SECTION 2: PROJECT GENERAL INFORMATION

5. Relative to your experience with similar project types, rate the following for this project (*with 1=Low to 6 =High*):

a) Level of design complexity:

Low								High

b) Level of construction complexity

Low							high

c) **Overall** success of this project

Low							high

SECTION 3: PROJECT ORGANIZATION

6. Select the project delivery system best matching the delivery of your project (*select one*):

□ Design-bid-build
□ Design-build
□ Construction manager at risk or Construction manager/general contractor
□ Integrated Project delivery
□ Other, please specify: ________________

Please select when each project participant contracted for the project (timing as based on percent of overall design completion): (CD :Schematic Design Phase, DD: Design Development Phase, CD: Construction Documents)

1. Preparation

	Pre-Design	Concept(0-15%)	SD (15-30%)	DD (30-60%)	CD (60-90%)	Bidding(Full CD)
Architect/ Designer						
GC,CM/GC or DB						
Subcontractors						

SECTION 4: TEAM PROCUREMENT & CONTRACTS

2. Please select how proposals were solicited from each project participant (*select all that apply*)

	Open Bid	Prequalification	1-Stage RFP	2-Stage RFP	Sole Source
Architect/ Designer					
GC					

CM/GC					
DB					

3. Please rank the following factors in terms of importance in the selection of each project participant *from 1 to 6, with 1 = most important to 6 = least important* (*type the no. in the table*)

Architect/Designer						
Price						
Technical proposal						
Similar Project						
Experience						
Interview Performance						

GC, CM/GC or DB						
Price						
Technical proposal						
Similar Project						
Experience						
Interview Performance						

Subcontractors						
Price						
Technical proposal						
Similar Project						
Experience						
Interview Performance						

4. Select the contract payment type used for the following project participants:

	lump Sum	unit Price	GMP	Fixed Fee	cost Plus
Architect/Designer					
GC, CM/GC					
Subcontractors					
Design Builder in DB Project					

5. Rate your overall satisfaction with the following (with 1=Not satisfied to 6=Exceed expectations):

a) Design process

Not satisfied							Exceed expectations

b) Construction process

Not satisfied							Exceed expectations

SECTION 5: CHANGE ORDER/DISPUTES

6. Based on your experience, how would you rate the following (with 1= low to 6=High):

a) Frequency of claims which arose at the field level

Low							high

b) Severity of claims which arose on project (*in terms of T**IME to resolve***)

Low							high

c) Severity of claims which arose on project (*in terms of **COST impact***)

Low							high

d) Severity (*in terms of cost impact and time to resolve*) of **largest dispute** which arose on project

Low							high

7. Were there any unresolved claims that escalated to a dispute requiring third party involvement?

O Yes O No O I do not know

8. What method(s) of dispute resolution was defined in the project contract conditions? (*check all that apply*)

O Negotiations
O Mediation/conciliation
O Arbitration
O Dispute Review Board
O Adjudication
O Mini-trial
O Expert determination
O Litigation
O Other(s), please specify: _______________

9. Has the project ever been in a form of dispute resolution, such as litigation?

O Yes O No O I do not know.

10. If Yes, please specify the state regulations and/or law that necessitated the selection of the dispute resolution method stated in the project contract. Provide a website url if available.

____

11. If yes, what type of Dispute Resolution Method? (*check all that apply*)

O Negotiations
O Mediation/conciliation
O Arbitration
O Dispute Review Board
O Adjudication
O Mini-trial
O Expert determination
O Litigation
O Other(s), please specify: _______________

12. How long did it take to resolve the dispute from the day a decision was taken among parties to seek a Dispute Resolution Method?

O less than a week O 1-2 weeks
O 2 weeks – 1 month O 1– 3 months
O 3 – 6 months O 6 month -1 year
O more than a year

13. What was the total final dollar amount of the largest dispute that was settled beyond the project/field level with involvement of a third party?

O <$20,000 O $20,001 - $50,000
O $50,001 - $100,000 O $100,001 - $250,000
O $250,001 - $500,000 O >$500,000

14. Were there any policies or laws that necessitated the selection of the dispute resolution method stated in the project contract?

O Yes O No,
O I do not know,

15. If No, on what basis were the dispute resolution methods stated in the contract document selected?

O It's the normal practice used by our company.
O It's the normal practice used by the other contracting party.
O The dispute resolution method(s) was selected for other reasons, please specify: ______________________________

SECTION 6: TEAM BEHAVIOR & COMMUNICATION

16. Indicate the owner's relationship type with:

	First time	Repeat
Architect/Designer	O	O
General Contractor (in case of DBB project)	O	O
Construction Manger (in case of CM/GC project)	O	O
Design Buildr (in case of DB Project)	O	O

17. Did the project team use a formal partnering agreement?

O Yes
O No
O I do not know

18. What were the characteristics of the partnering process? (mark all that apply)

O Contractually required partnering
O Kick-off meeting - (Facilitated)
O Kick-off meeting - (Non-facilitated)
O Multiple partnering meetings during project (Facilitated)
O Multiple partnering meetings during project (Non-facilitated)
O Formal charter or alliance agreement
O Formal issue resolution/escalation procedure
O Periodic partnering performance measurement assessment utilized
O Incentives for partnering performance
O Training on problem solving & joint decision-making

O Other, please specify: _______________

19. Please rate the following from 1 to 6:

a. Contractor's upper managerial support and responses

Ineffective							V-effective

b. Contractor's organization experience with this type of project

None							A lot

c. Experience and competence level of the contractor's project individuals

Low							High

d. Quality of the input shared during pre-construction phase of project

Low							High

e. Level of experience and effort of financial planners, and adequacy of financial plan

Low							High

f. Team's prior experience as a unit

low							High

g. Formality of communication among team members

Informal							Formal

h. Timeliness of communication

Never on time							Always on time

i. Electronic file & information sharing used by project team

Primarily paper-based							All electronic

j. Risks identification and allocation

Poor							Excellent

k. Adequacy of technical plans/specs

Poor							Excellent

20. Please evaluate trust between your organization and contractor (GC/DB/CMR):

a) Competency trust

Low							high

b) Organizational trust

Low							high

c) Relational trust

Low							high

SECTION 7: COST AND SCHEDULE

21. What was the original contract price?

a) <$100,000
b) $100,001 - $200,000
c) $200,001 - $300,000
d) $300,001 - $400,000
e) $400,001 - $500,000
f) >$500,001

22. What was the original duration of the project?
a) <2 months
b) 2 months – 6 months
c) 6 months – 1 year
d) 1 year – 1.5 years
e) 1.5 years – 2 years
f) > 2 years

23. What was the percentage of cost growth?
a) <10%
b) 0-10%
c) 10% - 20%
d) 20% - 30%
e) 30% - 40%
f) >40%

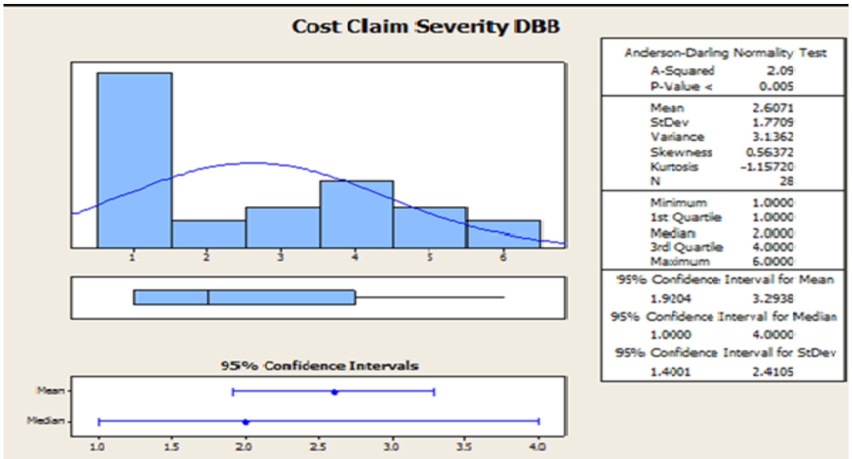
24. What was the percentage of schedule growth?
a) <10%
b) 0-10%
c) 10% - 20%
d) 20% - 30%
e) 30% - 40%
f) >40%

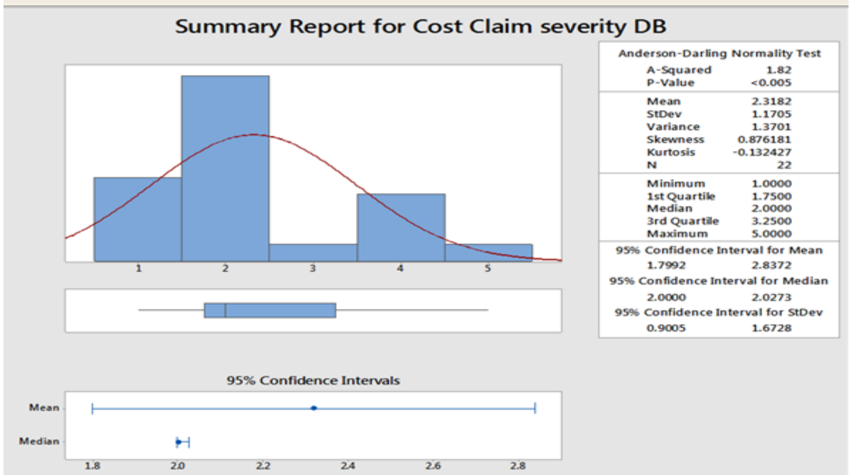
25. Would you be willing to be contacted for an interview to discuss additional information regarding the projects you provided:
O Yes
O No

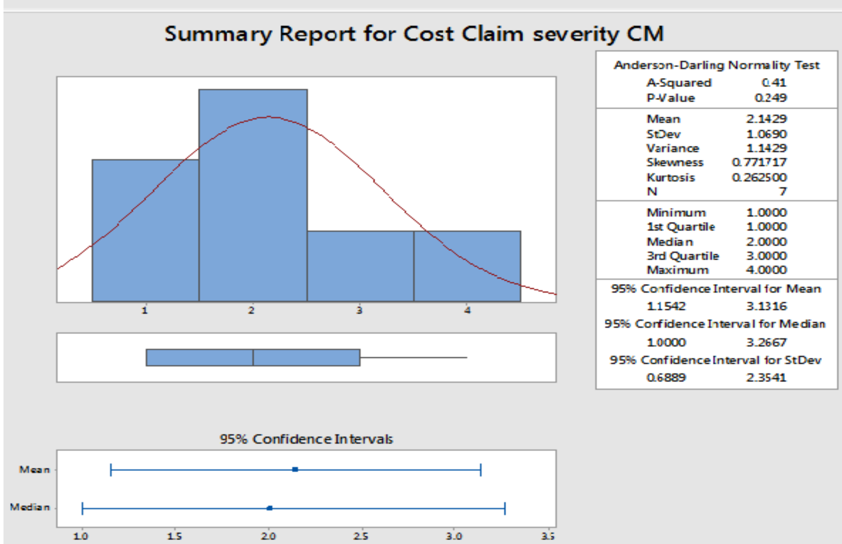
26. Please provide contact information:
a. Contact name:
b. Phone number:
c. Email address

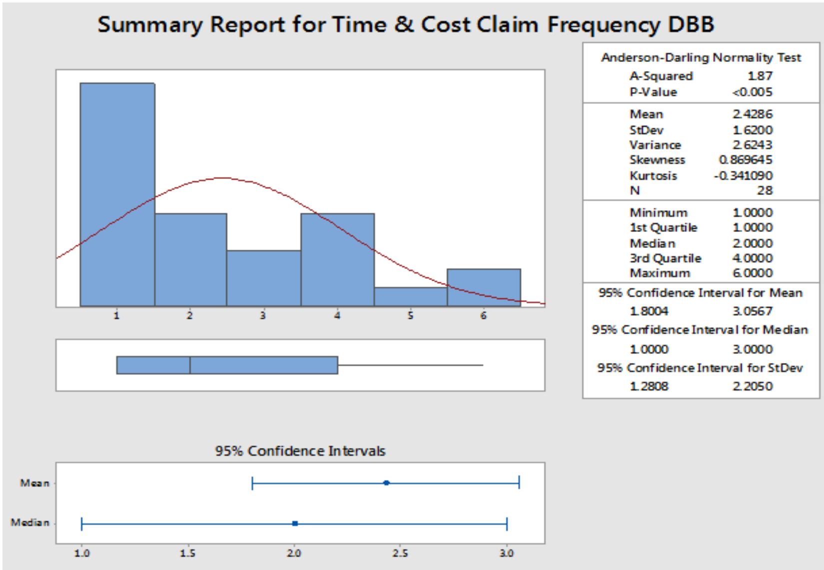
Thank you very much for your time and consideration to provide information.

Appendix C: Raw data and graphs





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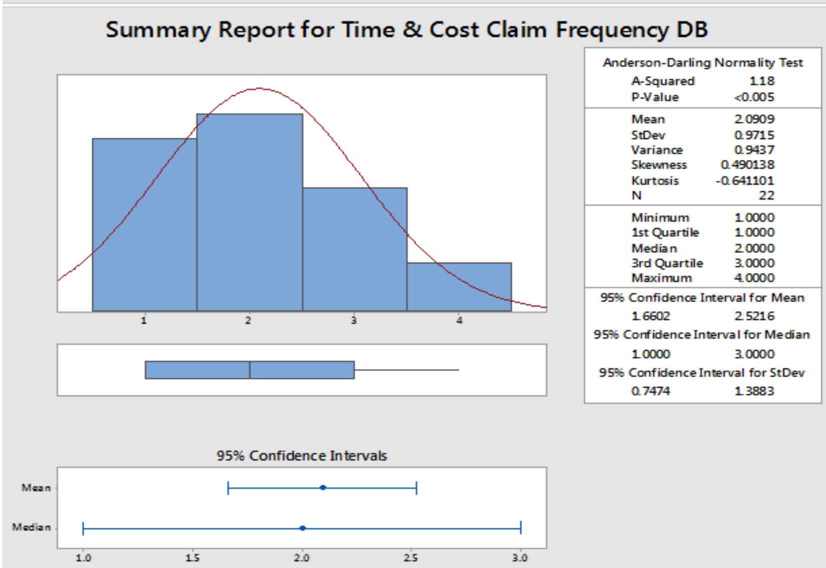
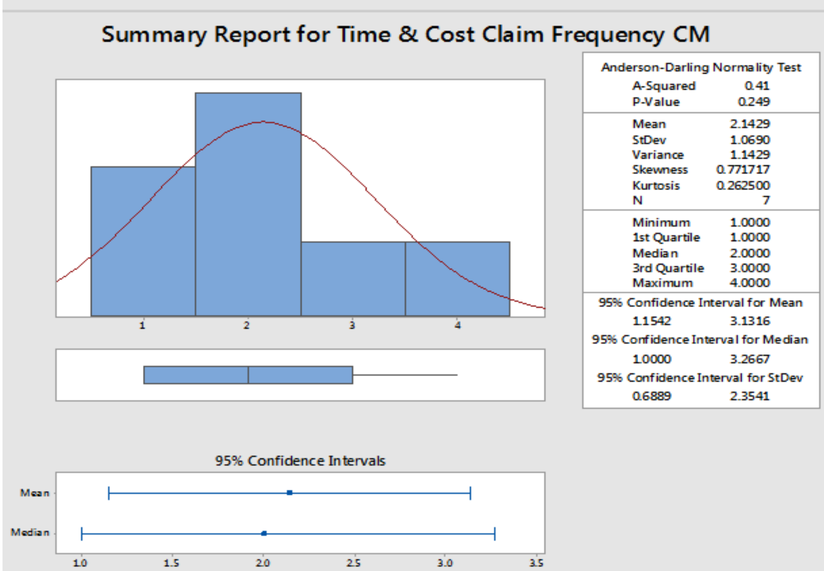
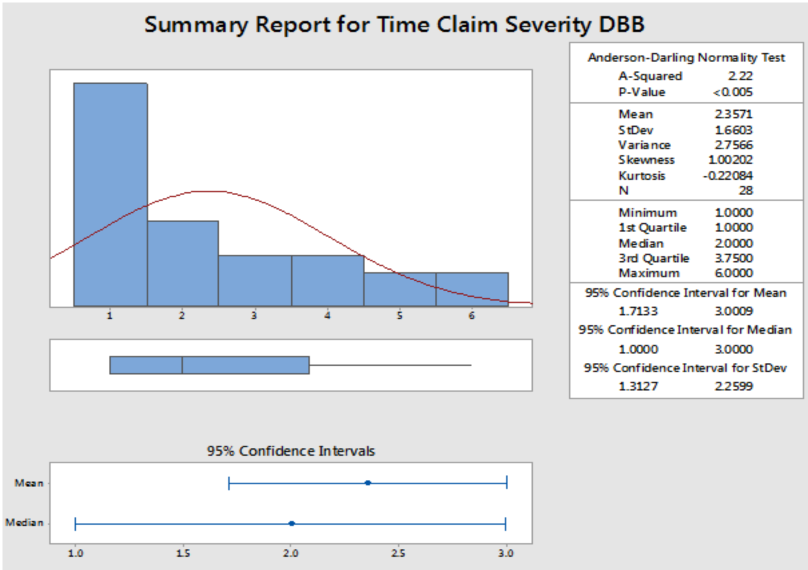
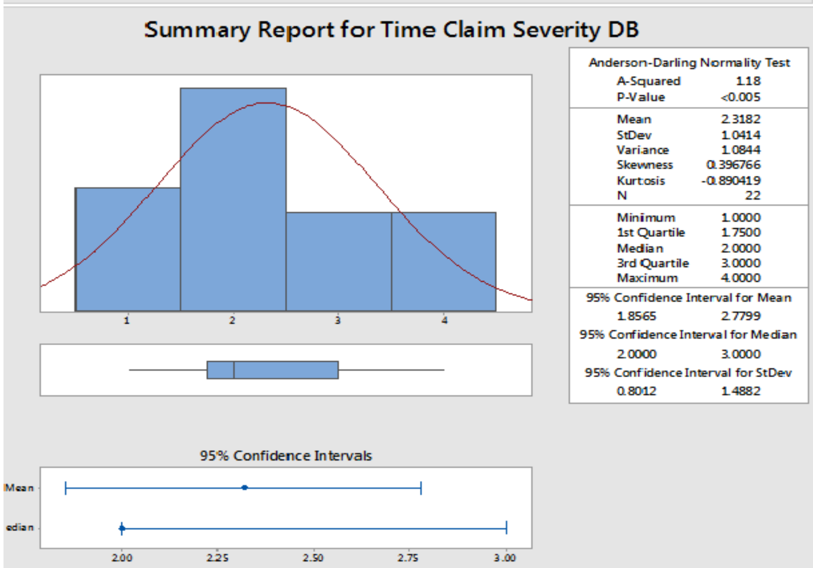
Anderson-Darling Normality Test
A-Squared 1.87
P-Value <0.005
Mean 2.4286
StDev 1.6200
Variance 2.6243
Skewness 0.869645
Kurtosis -0.341090
N 28
Minimum 1.0000
1st Quartile 1.0000
Median 2.0000
3rd Quartile 4.0000
Maximum 6.0000
95% Confidence Interval for Mean
1.8004 3.0567
95% Confidence Interval for Median
1.0000 3.0000
95% Confidence Interval for StDev
1.2808 2.2050
95% Confidence Intervals
Mean
Median


Summary Report for Time & Cost Claim Frequency DB
Anderson-Darling Normality Test
A-Squared 1.18
P-Value <0.005
Mean 2.0909
StDev 0.9715
Variance 0.9437
Skewness 0.490138
Kurtosis -0.641101
N 22
Minimum 1.0000
1st Quartile 1.0000
Median 2.0000
3rd Quartile 3.0000
Maximum 4.0000
95% Confidence Interval for Mean
1.6602 2.5216
95% Confidence Interval for Median
1.0000 3.0000
95% Confidence Interval for StDev
0.7474 1.3883
95% Confidence Intervals
Mean
Median


Summary Report for Time & Cost Claim Frequency CM
Anderson-Darling Normality Test
A-Squared 0.41
P-Value 0.249
Mean 2.1429
StDev 1.0690
Variance 1.1429
Skewness 0.771717
Kurtosis 0.262500
N 7
Minimum 1.0000
1st Quartile 1.0000
Median 2.0000
3rd Quartile 3.0000
Maximum 4.0000
95% Confidence Interval for Mean
1.1542 3.1316
95% Confidence Interval for Median
1.0000 3.2667
95% Confidence Interval for StDev
0.6889 2.3541
95% Confidence Intervals
Mean
Median


Summary Report for Time Claim Severity DBB
Anderson-Darling Normality Test
A-Squared 2.22
P-Value <0.005
Mean 2.3571
StDev 1.6603
Variance 2.7566
Skewness 1.00202
Kurtosis -0.22084
N 28
Minimum 1.0000
1st Quartile 1.0000
Median 2.0000
3rd Quartile 3.7500
Maximum 6.0000
95% Confidence Interval for Mean
1.7133 3.0009
95% Confidence Interval for Median
1.0000 3.0000
95% Confidence Interval for StDev
1.3127 2.2599
95% Confidence Intervals
Mean
Median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A-Squared 1.18
P-Value <0.005
Mean 2.3182
StDev 1.0414
Variance 1.0844
Skewness 0.396766
Kurtosis -0.890419
N 22
Minimum 1.0000
1st Quartile 1.7500
Median 2.0000
3rd Quartile 3.0000
Maximum 4.0000
95% Confidence Interval for Mean
1.8565 2.7799
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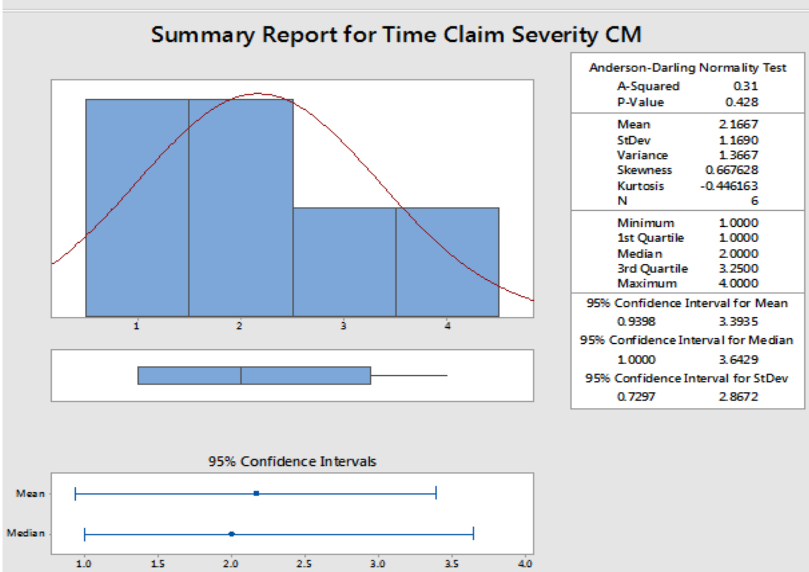
95% Confidence Intervals
Mean
edian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P-Value 0.428
Mean 2.1667
StDev 1.1690
Variance 1.3667
Skewness 0.667628
Kurtosis -0.446163
N 6
Minimum 1.0000
1st Quartile 1.0000
Median 2.0000
3rd Quartile 3.2500
Maximum 4.0000
95% Confidence Interval for Mean
0.9398 3.3935
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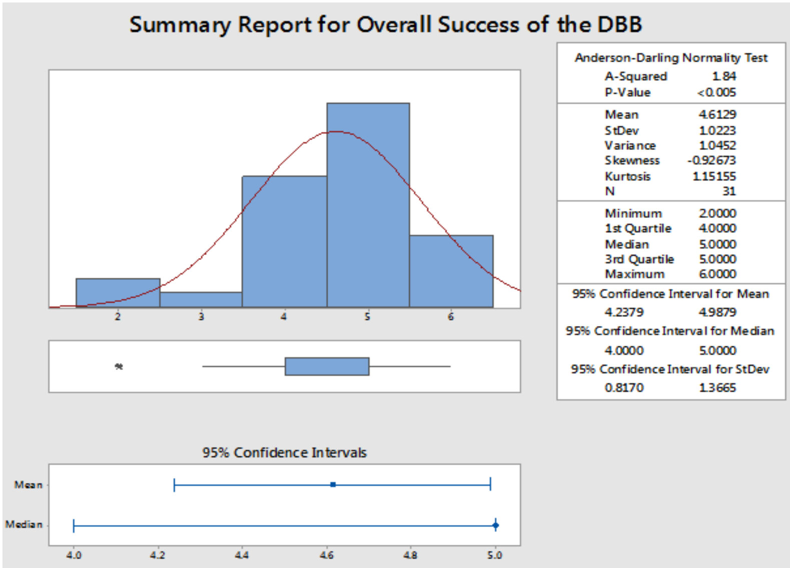
1.0000 3.6429
95% Confidence Interval for StDev
0.7297 2.8672
95% Confidence Intervals
Mean
Median


Summary Report for Overall Success of the DBB
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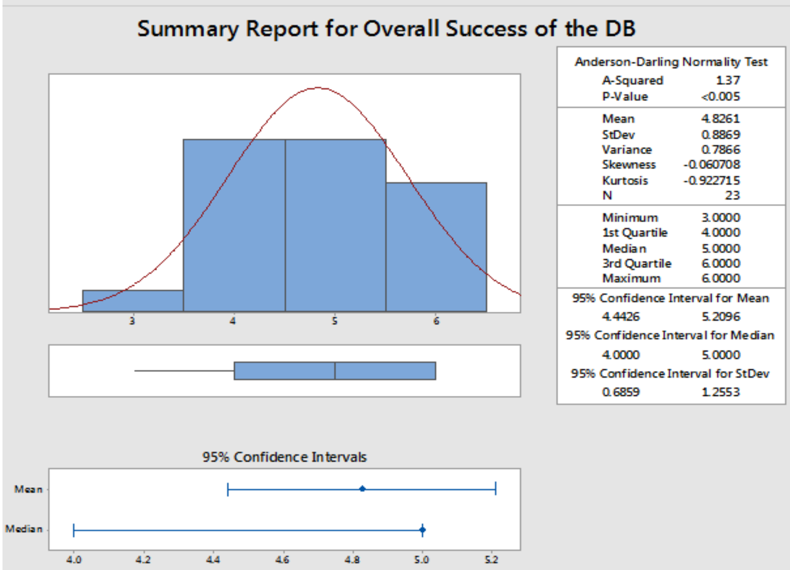
A-Squared 1.84
P-Value <0.005
Mean 4.6129
StDev 1.0223
Variance 1.0452
Skewness -0.92673
Kurtosis 1.15155
N 31
Minimum 2.0000
1st Quartile 4.0000
Median 5.0000
3rd Quartile 5.0000
Maximum 6.0000
95% Confidence Interval for Mean
4.2379 4.9879
95% Confidence Interval for Median
4.0000 5.0000
95% Confidence Interval for StDev
0.8170 1.3665
95% Confidence Intervals
Mean
Median


Summary Report for Overall Success of the DB
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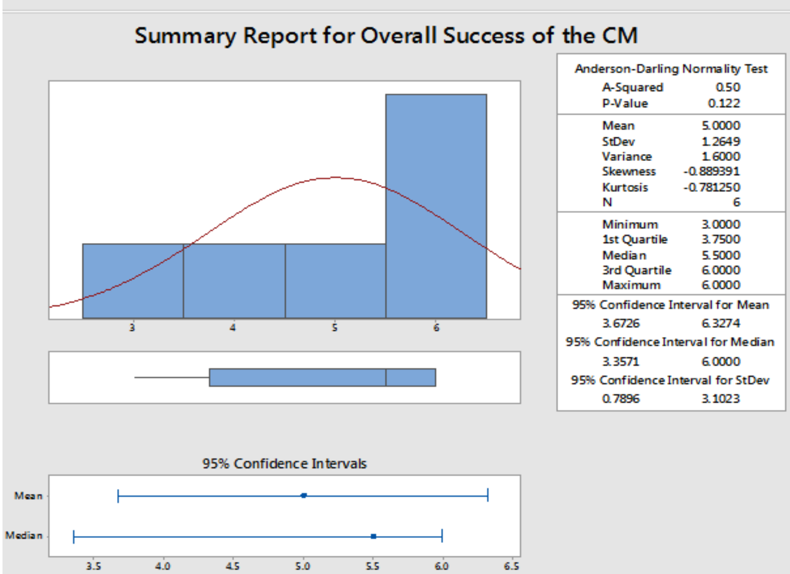
A-Squared 1.37
P-Value <0.005
Mean 4.8261
StDev 0.8869
Variance 0.7866
Skewness -0.060708
Kurtosis -0.922715
N 23
Minimum 3.0000
1st Quartile 4.0000
Median 5.0000
3rd Quartile 6.0000
Maximum 6.0000
95% Confidence Interval for Mean
4.4426 5.2096
95% Confidence Interval for Median
4.0000 5.0000
95% Confidence Interval for StDev
0.6859 1.2553
95% Confidence Intervals
Mean
Median


Summary Report for Overall Success of the CM
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A-Squared 0.50
P-Value 0.122
Mean 5.0000
StDev 1.2649
Variance 1.6000
Skewness -0.889391
Kurtosis -0.781250
N 6
Minimum 3.0000
1st Quartile 3.7500
Median 5.5000
3rd Quartile 6.0000
Maximum 6.0000
95% Confidence Interval for Mean
3.6726 6.3274
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95% Confidence Interval for StDev
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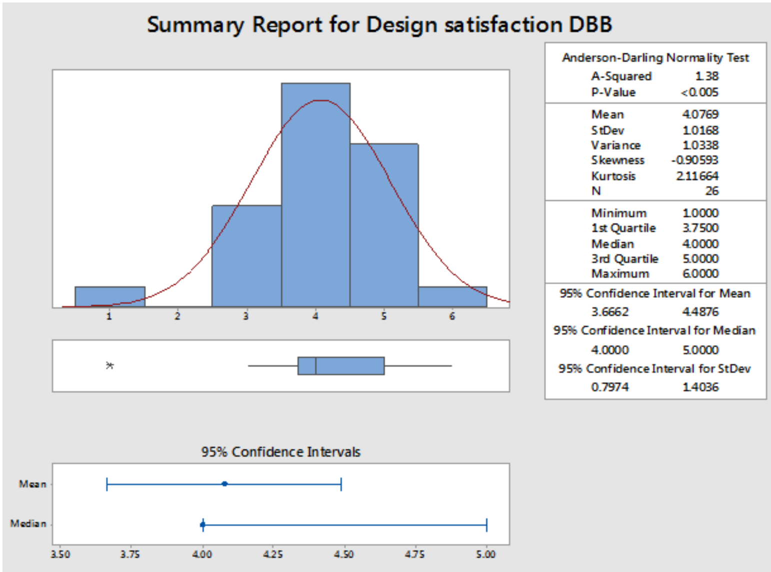
95% Confidence Intervals
Mean
Median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Anderson-Darling Normality Test
A-Squared 1.38
P-Value <0.005
Mean 4.0769
StDev 1.0168
Variance 1.0338
Skewness -0.90593
Kurtosis 2.11664
N 26
Minimum 1.0000
1st Quartile 3.7500
Median 4.0000
3rd Quartile 5.0000
Maximum 6.0000
95% Confidence Interval for Mean
3.6662 4.4876
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95% Confidence Interval for StDev
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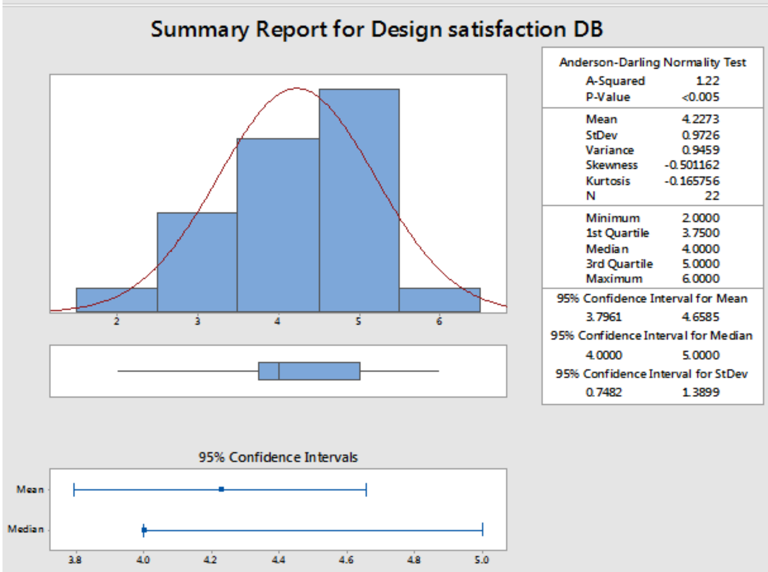
95% Confidence Intervals
Mean
Median


Summary Report for Design satisfaction DB
Anderson-Darling Normality Test
A-Squared 1.22
P-Value <0.005
Mean 4.2273
StDev 0.9726
Variance 0.9459
Skewness -0.501162
Kurtosis -0.165756
N 22
Minimum 2.0000
1st Quartile 3.7500
Median 4.0000
3rd Quartile 5.0000
Maximum 6.0000
95% Confidence Interval for Mean
3.7961 4.6585
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95% Confidence Interval for StDev
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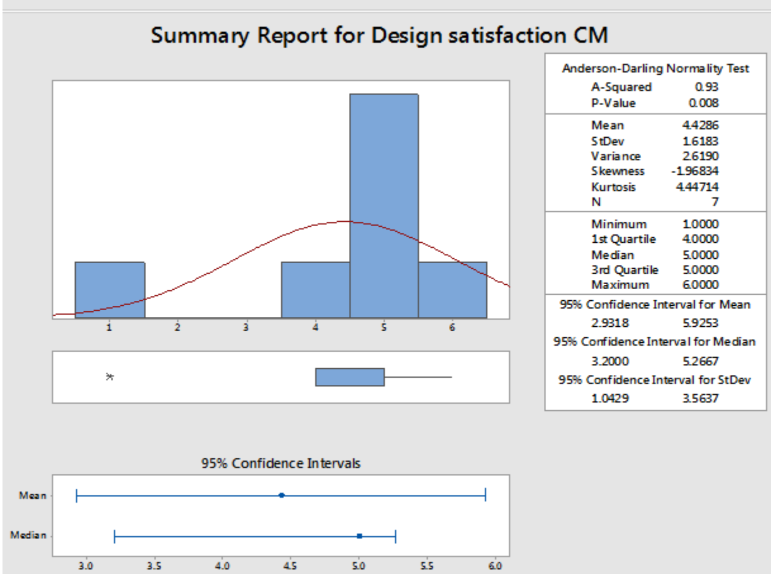
95% Confidence Intervals
Mean
Median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A-Squared 0.93
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StDev 1.6183
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Kurtosis 4.44714
N 7
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1st Quartile 4.0000
Median 5.0000
3rd Quartile 5.0000
Maximum 6.0000
95% Confidence Interval for Mean
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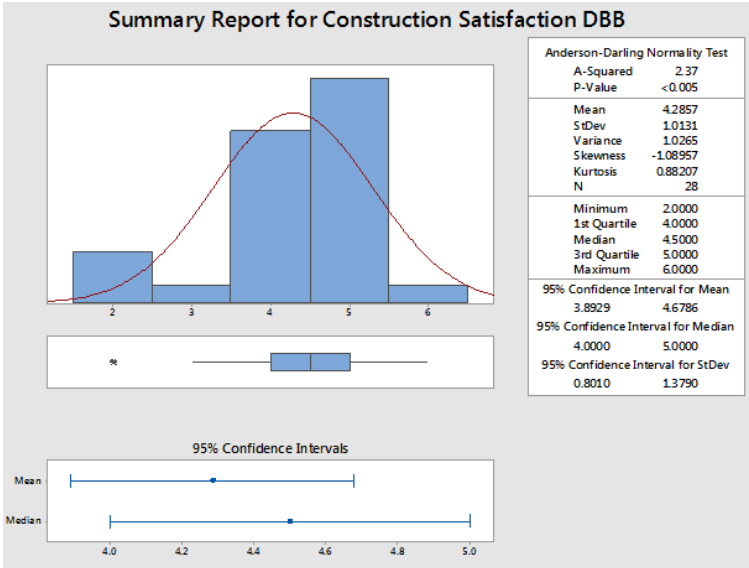
Mean
Median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A-Squared 2.37
P-Value <0.005
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Skewness -1.08957
Kurtosis 0.88207
N 28
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1st Quartile 4.0000
Median 4.5000
3rd Quartile 5.0000
Maximum 6.0000
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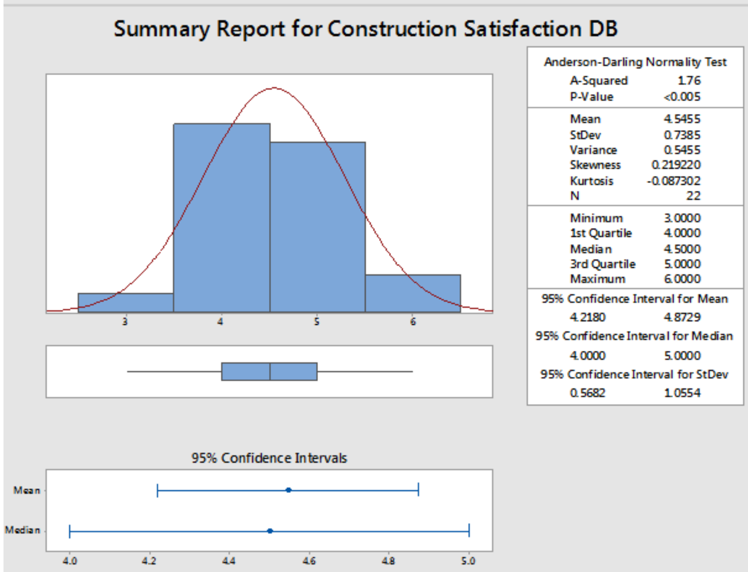
95% Confidence Intervals
Mean
Median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A-Squared 1.76
P-Value <0.005
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Variance 0.5455
Skewness 0.219220
Kurtosis -0.087302
N 22
Minimum 3.0000
1st Quartile 4.0000
Median 4.5000
3rd Quartile 5.0000
Maximum 6.0000
95% Confidence Interval for Mean
4.2180 4.8729
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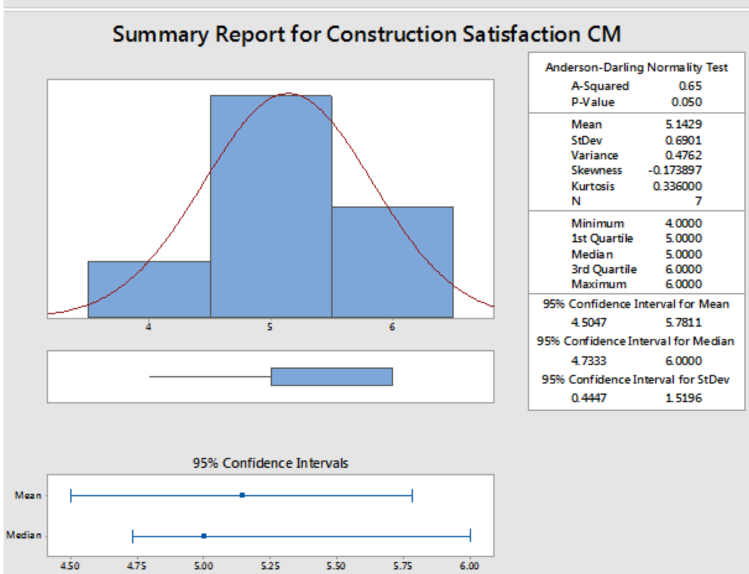
Mean
Median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A-Squared 0.65
P-Value 0.050
Mean 5.1429
StDev 0.6901
Variance 0.4762
Skewness -0.173897
Kurtosis 0.336000
N 7
Minimum 4.0000
1st Quartile 5.0000
Median 5.0000
3rd Quartile 6.0000
Maximum 6.0000
95% Confidence Interval for Mean
4.5047 5.7811
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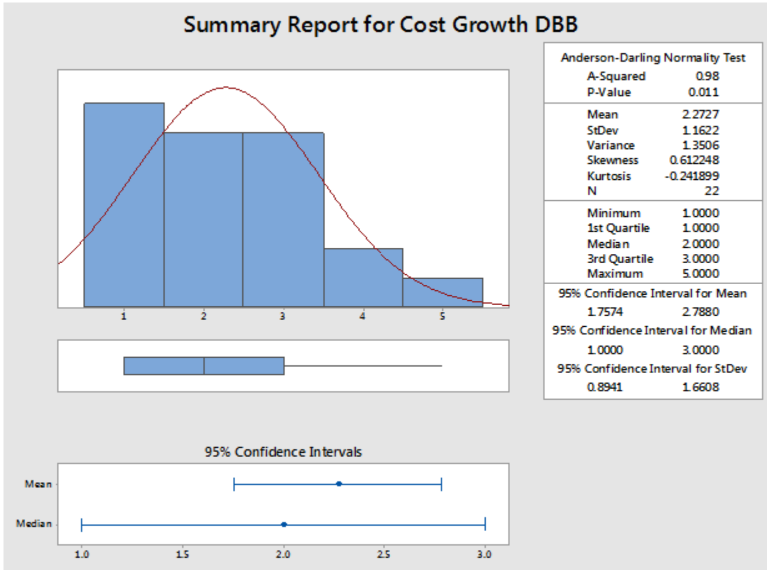
Mean
Median


Summary Report for Cost Growth DBB
Anderson-Darling Normality Test
A-Squared 0.98
P-Value 0.011
Mean 2.2727
StDev 1.1622
Variance 1.3506
Skewness 0.612248
Kurtosis -0.241899
N 22
Minimum 1.0000
1st Quartile 1.0000
Median 2.0000
3rd Quartile 3.0000
Maximum 5.0000
95% Confidence Interval for Mean
1.7574 2.7880
95% Confidence Interval for Median
1.0000 3.0000
95% Confidence Interval for StDev
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95% Confidence Intervals
Mean
Median
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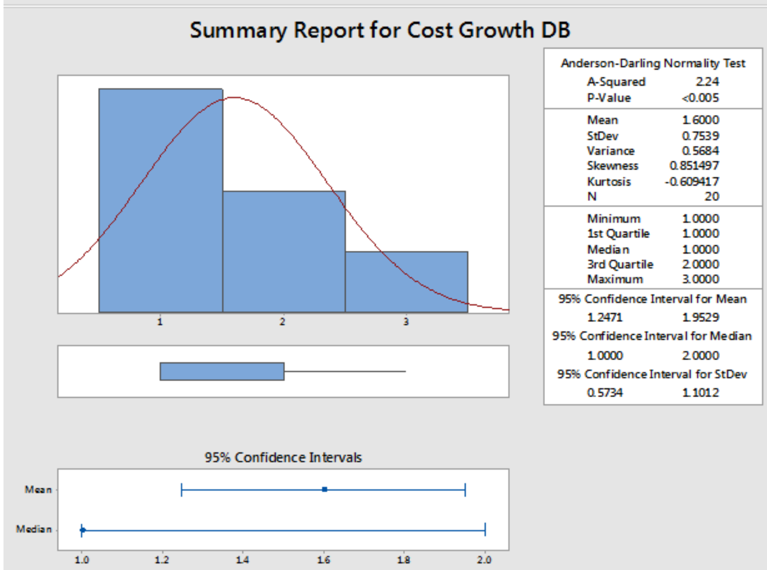
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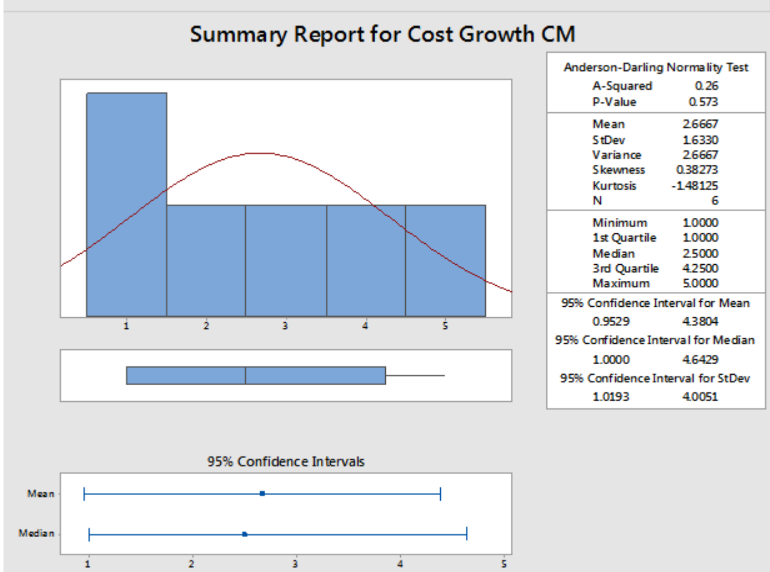
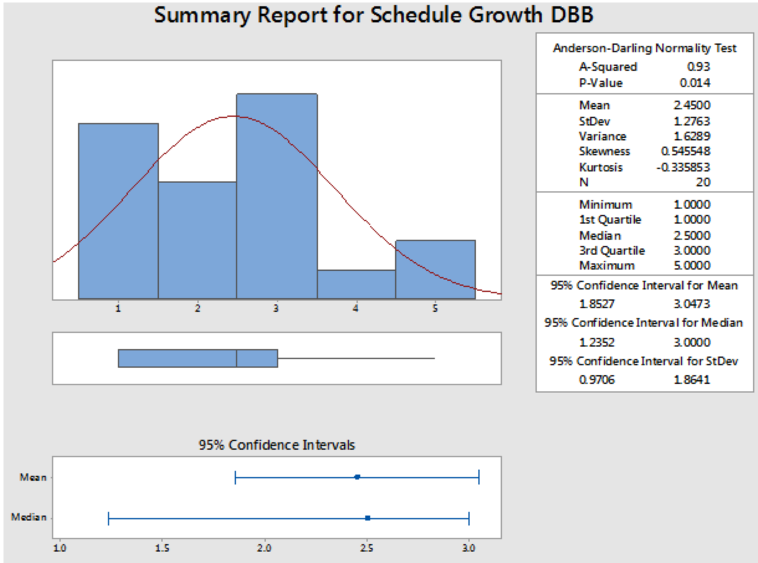
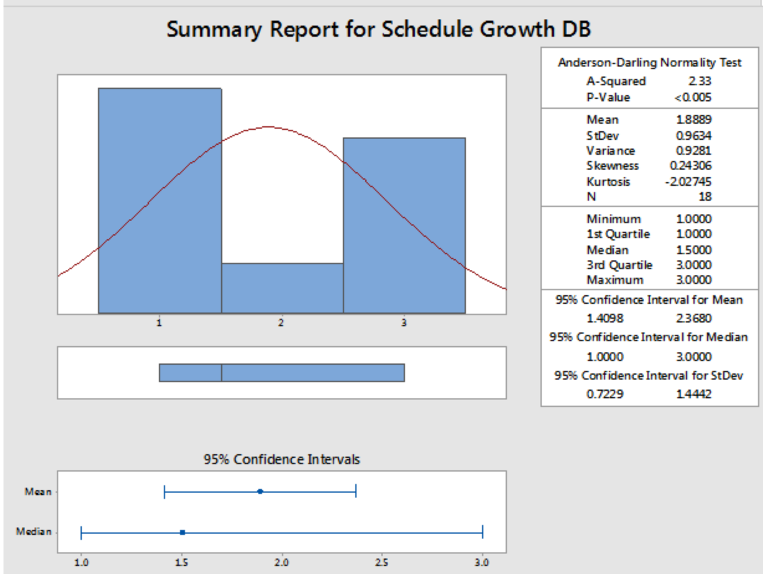
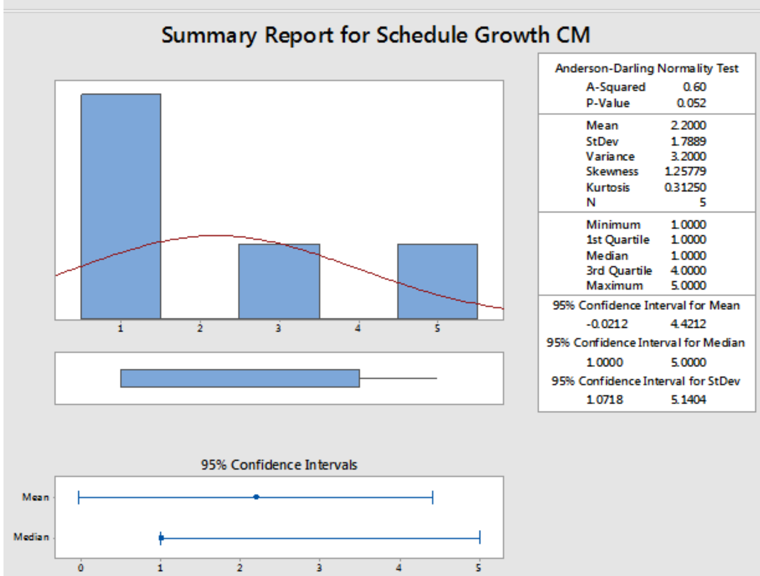
StDev 0.7539
Variance 0.5684
Skewness 0.851497
Kurtosis -0.609417
N 20
Minimum 1.0000
1st Quartile 1.0000
Median 1.0000
3rd Quartile 2.0000
Maximum 3.0000
95% Confidence Interval for Mean
1.2471 1.9529
95% Confidence Interval for Median
1.0000 2.0000
95% Confidence Interval for StDev
0.5734 1.1012
1 2 3
95% Confidence Intervals
Mean
Median
1.0 1.2 1.4 1.6 1.8 2.0


Summary Report for Cost Growth CM
Anderson-Darling Normality Test
A-Squared 0.26
P-Value 0.573
Mean 2.6667
StDev 1.6330
Variance 2.6667
Skewness 0.38273
Kurtosis -1.48125
N 6
Minimum 1.0000
1st Quartile 1.0000
Median 2.5000
3rd Quartile 4.2500
Maximum 5.0000
95% Confidence Interval for Mean
0.9529 4.3804
95% Confidence Interval for Median
1.0000 4.6429
95% Confidence Interval for StDev
1.0193 4.0051
1 2 3 4 5
95% Confidence Intervals
Mean
Median
1 2 3 4 5


Summary Report for Schedule Growth DBB
Anderson-Darling Normality Test
A-Squared 0.93
P-Value 0.014
Mean 2.4500
StDev 1.2763
Variance 1.6289
Skewness 0.545548
Kurtosis -0.335853
N 20
Minimum 1.0000
1st Quartile 1.0000
Median 2.5000
3rd Quartile 3.0000
Maximum 5.0000
95% Confidence Interval for Mean
1.8527 3.0473
95% Confidence Interval for Median
1.2352 3.0000
95% Confidence Interval for StDev
0.9706 1.8641
95% Confidence Intervals
Mean
Median


Summary Report for Schedule Growth DB
Anderson-Darling Normality Test
A-Squared 2.33
P-Value <0.005
Mean 1.8889
StDev 0.9634
Variance 0.9281
Skewness 0.24306
Kurtosis -2.02745
N 18
Minimum 1.0000
1st Quartile 1.0000
Median 1.5000
3rd Quartile 3.0000
Maximum 3.0000
95% Confidence Interval for Mean
1.4098 2.3680
95% Confidence Interval for Median
1.0000 3.0000
95% Confidence Interval for StDev
0.7229 1.4442
95% Confidence Intervals
Mean
Median


Summary Report for Schedule Growth CM
Anderson-Darling Normality Test
A-Squared 0.60
P-Value 0.052
Mean 2.2000
StDev 1.7889
Variance 3.2000
Skewness 1.25779
Kurtosis 0.31250
N 5
Minimum 1.0000
1st Quartile 1.0000
Median 1.0000
3rd Quartile 4.0000
Maximum 5.0000
95% Confidence Interval for Mean
-0.0212 4.4212
95% Confidence Interval for Median
1.0000 5.0000
95% Confidence Interval for StDev
1.0718 5.1404
95% Confidence Intervals
Mean
Median

One way ANOVA: Cost Claim Severity DBB, Cost Claim severity DB, Cost Claim severity CM

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Cost Claim Severity DBB, Cost Claim severity DB, Cost Claim severity CM

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	1.727	0.8633	0.39	0.681
Error	54	120.308	2.2279		
Total	56	122.035			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.49263	1.41%	0.00%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Cost Claim Severity DBB	28	2.607	1.771	(2.042, 3.173)
Cost Claim severity DB	22	2.318	1.171	(1.680, 2.956)
Cost Claim severity CM	7	2.143	1.069	(1.012, 3.274)

Pooled StDev = 1.49263

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping

Cost Claim Severity DBB	28	2.607	A
Cost Claim severity DB	22	2.318	A
Cost Claim severity CM	7	2.143	A

Means that do not share a letter are significantly different.

One-way ANOVA: Time Claim Severity DBB, Time Claim Severity DB, Time Claim Severity CM

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Time Claim Severity DBB, Time Claim Severity DB, Time Claim Severity CM

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	0.180	0.08983	0.05	0.955
Error	53	104.035	1.96292		
Total	55	104.214			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.40104	0.17%	0.00%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Time Claim Severity DBB	28	2.357	1.660	(1.826, 2.888)
Time Claim Severity DB	22	2.318	1.041	(1.719, 2.917)
Time Claim Severity CM	6	2.167	1.169	(1.019, 3.314)

Pooled StDev = 1.40104

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
Time Claim Severity DBB	28	2.357	A
Time Claim Severity DB	22	2.318	A
Time Claim Severity CM	6	2.167	A

Means that do not share a letter are significantly different.

One-way ANOVA: Time and Cost Claim Frequency DBB, Time and Cost Claim Frequency DB, Time and Cost Claim Frequency CM

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Time & Cost Claim Frequency DBB, Time & Cost Claim Frequency DB, Time & Cost Claim Frequency CM

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	1.520	0.7601	0.42	0.659
Error	54	97.532	1.8062		
Total	56	99.053			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.34393	1.53%	0.00%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Time & Cost Claim Frequency DBB	28	2.429	1.620	(1.919, 2.938)
Time & Cost Claim Frequency DB	22	2.091	0.971	(1.516, 2.665)
Time & Cost Claim Frequency CM	7	2.143	1.069	(1.124, 3.161)

Pooled StDev = 1.34393

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
Time & Cost Claim Frequency DBB	28	2.429	A
Time & Cost Claim Frequency CM	7	2.143	A
Time & Cost Claim Frequency DB	22	2.091	A

Means that do not share a letter are significantly different.

One-way ANOVA: Overall Successful of DBB, Overall Successful of DB, Overall Successful of CM

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Overall Success of the DBB, Overall Success of the DB, Overall Success of the CM

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	1.074	0.5371	0.54	0.586
Error	57	56.659	0.9940		
Total	59	57.733			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.997006	1.86%	0.00%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Overall Success of the DBB	31	4.613	1.022	(4.254, 4.971)
Overall Success of the DB	23	4.826	0.887	(4.410, 5.242)
Overall Success of the CM	6	5.000	1.265	(4.185, 5.815)

Pooled StDev = 0.997006

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
Overall Success of the CM	6	5.000	A
Overall Success of the DB	23	4.826	A
Overall Success of the DBB	31	4.613	A

Means that do not share a letter are significantly different.

One-way ANOVA: Design Satisfaction of DBB, Design Satisfaction of DB, Design Satisfaction of CM

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Design satisfaction DBB, Design satisfaction DB, Design satisfaction CM

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	0.7577	0.3789	0.32	0.727
Error	52	61.4241	1.1812		
Total	54	62.1818			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.08685	1.22%	0.00%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Design satisfaction DBB	26	4.077	1.017	(3.649, 4.505)
Design satisfaction DB	22	4.227	0.973	(3.762, 4.692)
Design satisfaction CM	7	4.429	1.618	(3.604, 5.253)

Pooled StDev = 1.08685

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
Design satisfaction CM	7	4.429	A
Design satisfaction DB	22	4.227	A
Design satisfaction DBB	26	4.077	A

Means that do not share a letter are significantly different.

One-way ANOVA: Constriction Satisfaction of DBB, Construction Satisfaction of DB, Construction Satisfaction of CM

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Construction Satisfaction DBB, Construction Satisfaction DB, Construction Satisfaction CM

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	4.220	2.1098	2.71	0.076
Error	54	42.026	0.7783		
Total	56	46.246			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.882190	9.12%	5.76%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Construction Satisfaction DBB	28	4.286	1.013	(3.951, 4.620)
Construction Satisfaction DB	22	4.545	0.739	(4.168, 4.923)
Construction Satisfaction CM	7	5.143	0.690	(4.474, 5.811)

Pooled StDev = 0.882190

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
Construction Satisfaction CM	7	5.143	A
Construction Satisfaction DB	22	4.545	A
Construction Satisfaction DBB	28	4.286	A

Means that do not share a letter are significantly different.

One-way ANOVA: Cost Growth of DBB, Cost Growth of DB and Cost Growth of CM

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	$\alpha = 0.05$

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Cost Growth DBB, Cost Growth DB, Cost Growth CM

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	7.420	3.710	3.18	0.051
Error	45	52.497	1.167		
Total	47	59.917			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.08009	12.38%	8.49%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Cost Growth DBB	22	2.273	1.162	(1.809, 2.737)
Cost Growth DB	20	1.600	0.754	(1.114, 2.086)
Cost Growth CM	6	2.667	1.633	(1.779, 3.555)

Pooled StDev = 1.08009

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
Cost Growth CM	6	2.667	A
Cost Growth DBB	22	2.273	A
Cost Growth DB	20	1.600	A

Means that do not share a letter are significantly different.

One-way ANOVA: Schedule Growth of DBB, Schedule Growth of DB, Schedule Growth of CM

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	$\alpha = 0.05$

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Schedule Growth DBB, Schedule Growth DB, Schedule Growth CM

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	2.984	1.492	1.00	0.376
Error	40	59.528	1.488		
Total	42	62.512			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.21992	4.77%	0.01%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Schedule Growth DBB	20	2.450	1.276	(1.899, 3.001)
Schedule Growth DB	18	1.889	0.963	(1.308, 2.470)
Schedule Growth CM	5	2.200	1.789	(1.097, 3.303)

Pooled StDev = 1.21992

Tukey Pairwise Comparisons

Grouping Information Using the Tukey Method and 95% Confidence

Factor	N	Mean	Grouping
Schedule Growth DBB	20	2.450	A
Schedule Growth CM	5	2.200	A
Schedule Growth DB	18	1.889	A

Means that do not share a letter are significantly different.

Two-sample T for Cost Claim Severity DBB vs Cost Claim severity DB

	N	Mean	StDev	SE Mean
Cost Claim Severity DBB	28	2.61	1.77	0.33
Cost Claim severity DB	22	2.32	1.17	0.25

Difference = μ (Cost Claim Severity DBB) - μ (Cost Claim severity DB)
Estimate for difference: 0.289
95% CI for difference: (-0.551, 1.129)
T-Test of difference = 0 (vs ≠): T-Value = 0.69 P-Value = 0.492 DF = 46

Two-sample T for Time Claim Severity DBB vs Time Claim Severity DB

	N	Mean	StDev	SE Mean

	N	Mean	StDev	SE Mean
Time Claim Severity DBB	28	2.36	1.66	0.31
Time Claim Severity DB	22	2.32	1.04	0.22

Difference = μ (Time Claim Severity DBB) - μ (Time Claim Severity DB)
Estimate for difference: 0.039
95% CI for difference: (-0.735, 0.813)
T-Test of difference = 0 (vs ≠): T-Value = 0.10 P-Value = 0.920 DF = 45

Two-sample T for Time & Cost Claim Frequency DBB vs Time & Cost Claim Frequency DB

	N	Mean	StDev	SE Mean
Time & Cost Claim Freque	28	2.43	1.62	0.31
Time & Cost Claim Freque	22	2.091	0.971	0.21

Difference = μ (Time & Cost Claim Frequency DBB) - μ (Time & Cost Claim Frequency DB)
Estimate for difference: 0.338
95% CI for difference: (-0.407, 1.082)
T-Test of difference = 0 (vs ≠): T-Value = 0.91 P-Value = 0.366 DF = 45

Two-sample T for Overall Success of the DBB vs Overall Success of the DB

	N	Mean	StDev	SE Mean
Overall Success of the D	31	4.61	1.02	0.18
Overall Success of the D	23	4.826	0.887	0.18

Difference = μ (Overall Success of the DBB) - μ (Overall Success of the DB)
Estimate for difference: -0.213
95% CI for difference: (-0.737, 0.310)
T-Test of difference = 0 (vs ≠): T-Value = -0.82 P-Value = 0.417 DF = 50

Two-sample T for Construction Satisfaction DBB vs Construction Satisfaction DB

	N	Mean	StDev	SE Mean
Construction Satisfactio	28	4.29	1.01	0.19
Construction Satisfactio	22	4.545	0.739	0.16

Difference = μ (Construction Satisfaction DBB) - μ (Construction Satisfaction DB)
Estimate for difference: -0.260
95% CI for difference: (-0.758, 0.239)
T-Test of difference = 0 (vs ≠): T-Value = -1.05 P-Value = 0.300 DF = 47

Two-sample T for Cost Growth DBB vs Cost Growth DB

	N	Mean	StDev	SE Mean
Cost Growth DBB	22	2.27	1.16	0.25
Cost Growth DB	20	1.600	0.754	0.17

Difference = μ (Cost Growth DBB) - μ (Cost Growth DB)
Estimate for difference: 0.673
95% CI for difference: (0.065, 1.281)
T-Test of difference = 0 (vs ≠): T-Value = 2.24 P-Value = 0.031 DF = 36

Two-sample T for Schedule Growth DBB vs Schedule Growth DB

	N	Mean	StDev	SE Mean
Schedule Growth DBB	20	2.45	1.28	0.29
Schedule Growth DB	18	1.889	0.963	0.23

Difference = μ (Schedule Growth DBB) - μ (Schedule Growth DB)
Estimate for difference: 0.561
95% CI for difference: (-0.180, 1.302)
T-Test of difference = 0 (vs ≠): T-Value = 1.54 P-Value = 0.133 DF = 34

Two-Sample T-Test and CI: Cost Claim Severity DBB, Cost Claim Severity DB&CM

Two-sample T for Cost Claim Severity DBB vs Cost Claim Severity DB&CM

	N	Mean	StDev	SE Mean
Cost Claim Severity DBB	28	2.61	1.77	0.33
Cost Claim Severity DB&C	29	2.28	1.13	0.21

```
     Difference = μ (Cost Claim Severity DBB) - μ (Cost Claim
Severity DB&CM)
     Estimate for difference:  0.331
     95% CI for difference:  (-0.464, 1.127)
     T-Test of difference = 0 (vs ≠): T-Value = 0.84  P-Value =
0.406  DF = 45
```

Two-Sample T-Test and CI: Time Claim Severity DBB, Time Claim severity DB&CM

```
     Two-sample T for Time Claim Severity DBB vs Time Claim
severity DB&CM

                                N  Mean  StDev  SE Mean
     Time Claim Severity DBB   28  2.36   1.66     0.31
     Time Claim severity DB&C  28  2.29   1.05     0.20


     Difference = μ (Time Claim Severity DBB) - μ (Time Claim
severity DB&CM)
     Estimate for difference:  0.071
     95% CI for difference:  (-0.676, 0.819)
     T-Test of difference = 0 (vs ≠): T-Value = 0.19  P-Value =
0.848  DF = 45
```

Two-Sample T-Test and CI: Time & Cost Claim Frequency DBB, Time & Cost Frequency DB&CM

```
     Two-sample T for Time & Cost Claim Frequency DBB vs Time &
Cost Frequency DB&CM

                                N   Mean  StDev  SE Mean
     Time & Cost Claim Freque  28   2.43   1.62     0.31
     Time & Cost Frequency DB  29  2.103  0.976     0.18


     Difference = μ (Time & Cost Claim Frequency DBB) - μ (Time
& Cost Frequency DB&CM)
     Estimate for difference:  0.325
     95% CI for difference:  (-0.392, 1.042)
     T-Test of difference = 0 (vs ≠): T-Value = 0.91  P-Value =
0.366  DF = 44
```

Two-Sample T-Test and CI: Overall Success of the DBB, Overall Success DB&CM

Two-sample T for Overall Success of the DBB vs Overall Success DB&CM

	N	Mean	StDev	SE Mean
Overall Success of the D	31	4.61	1.02	0.18
Overall Success DB&CM	29	4.862	0.953	0.18

Difference = μ (Overall Success of the DBB) - μ (Overall Success DB&CM)
Estimate for difference: -0.249
95% CI for difference: (-0.760, 0.262)
T-Test of difference = 0 (vs ≠): T-Value = -0.98 P-Value = 0.333 DF = 5

Two-Sample T-Test and CI: Design satisfaction DBB, Design Satisfaction DB&CM

Two-sample T for Design satisfaction DBB vs Design Satisfaction DB&CM

	N	Mean	StDev	SE Mean
Design satisfaction DBB	26	4.08	1.02	0.20
Design Satisfaction DB&C	29	4.28	1.13	0.21

Difference = μ (Design satisfaction DBB) - μ (Design Satisfaction DB&CM)
Estimate for difference: -0.199
95% CI for difference: (-0.780, 0.382)
T-Test of difference = 0 (vs ≠): T-Value = -0.69 P-Value = 0.495 DF = 52

Two-Sample T-Test and CI: Construction Satisfaction DBB, Construction Satisfaction DB&CM

Two-sample T for Construction Satisfaction DBB vs Construction Satisfaction DB&CM

	N	Mean	StDev	SE Mean
Construction Satisfactio	28	4.29	1.01	0.19
Construction Satisfactio	29	4.690	0.761	0.14

Difference = μ (Construction Satisfaction DBB) - μ (Construction Satisfaction DB&CM)
Estimate for difference: -0.404

95% CI for difference: (-0.882, 0.074)
T-Test of difference = 0 (vs ≠): T-Value = -1.70 P-Value = 0.096 DF = 50

Two-Sample T-Test and CI: Cost Growth DBB, Cost Growth DB&CM

Two-sample T for Cost Growth DBB vs Cost Growth DB&CM

	N	Mean	StDev	SE Mean
Cost Growth DBB	22	2.27	1.16	0.25
Cost Growth DB&CM	26	1.85	1.08	0.21

Difference = μ (Cost Growth DBB) - μ (Cost Growth DB&CM)
Estimate for difference: 0.427
95% CI for difference: (-0.232, 1.085)
T-Test of difference = 0 (vs ≠): T-Value = 1.31 P-Value = 0.198 DF = 43

Two-Sample T-Test and CI: Schedule Growth DBB, Schedule Growth DB&CM

Two-sample T for Schedule Growth DBB vs Schedule Growth DB&CM

	N	Mean	StDev	SE Mean
Schedule Growth DBB	20	2.45	1.28	0.29
Schedule Growth DB&CM	23	1.96	1.15	0.24

Difference = μ (Schedule Growth DBB) - μ (Schedule Growth DB&CM)
Estimate for difference: 0.493
95% CI for difference: (-0.260, 1.247)
T-Test of difference = 0 (vs ≠): T-Value = 1.33 P-Value = 0.193 DF = 38