2016

A framework for value for money assessment on public private partnership mega-projects

Philip J. Barutha
Iowa State University

A framework for value for money assessment on public private partnership mega-projects

by

Philip J. Barutha

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Civil Engineering (Construction Engineering and Management)

Program of Study Committee:
Douglas D. Gransberg, Major Professor
Hyung Seok "David" Jeong
Peter Savolainen

Iowa State University

Ames, Iowa

2016

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

LIST OF EQUATIONS

Page

NOMENCLATURE

DB	Design Build
DBB	Design Bid Build
DBF	Design Build Finance
DBFM	Design Build Finance Maintain
DBFOM	Design Build Finance Operate Maintain
DOT	Department of Transportation
FHWA	Federal Highway Administration
MDOT	Michigan Department of Transportation
MoDOT	Missouri Department of Transportation
NZ	New Zealand
NZTA	New Zealand Transport Agency
PennDOT	Pennsylvania Department of Transportation
P3	Public Private Partnership
PSC	Public Sector Comparator
RBR	Rapid Bridge Replacement Project
S&S	Safe and Sound Project
SB	Shadow Bid
VfM	Value for Money
VAP3	Virginia Office of Public Private Partnerships

ACKNOWLEDGEMENTS

First, I would like to express my sincere gratitude to my committee chair, Dr. Douglas Gransberg, for his continuous support, invaluable guidance, and steady hand throughout the course of this thesis. My academic, professional, and personal life have been greatly enriched by his mentorship.

Additionally, I would like to thank my committee members, Dr. David Jeong and Dr. Peter Savolainen, for the time and support they have offered to me. A special thanks to Dr. Eric Scheepbouwer of University of Canterbury and Dr. Michael Garvin of Virginia Tech University for their additional guidance and support.

I would like to thank all the professional members of industry who have provided me invaluable information, knowledge, wisdom, and guidance in my work to complete this thesis. There are many who have contributed to this work.

Finally, thanks to my family, colleagues and friends for their support.

ABSTRACT

Much of the transportation infrastructure was built in the middle of the 20th century using traditional design-bid-build (DBB) procurement method. Public agencies advertised prescriptive construction documents composed of project plan sets and specifications to be competitively bid by private contractors where the low bidders would then build the infrastructure to the specified design. The award of the contract was based on the lowest price to complete the project to the specified design. Throughout the nation, much of the infrastructure has reached or exceeded its design life. Aging infrastructure in the United States has drawn attention from national politicians to local agencies to the public users themselves. Public transportation demands have increased since those measured in the mid-20th century and used to design the national transportation network. Hence, public agencies are now looking at ways to more effectively maintain, replace, and expand the existing road network to support local economy and road user demands. As agencies attempt to keep pace with these increasing demands, they find themselves challenged to find the necessary resources to accommodate the demand. The constraints range from identifying the necessary public funding to obtaining the required number of qualified public employees.

The private sector offers many resources that are needed by public agencies as they work to find solutions to the aforementioned challenges, including providing access to private financing. Public agencies can partner with a private organization through the use of a public private partnership (P3). P3s are contractual arrangements between the public and private to where some of the public service is provided by the private sector. P3s are becoming an attractive option for public agencies. Public agencies are stewards of public

dollars and must assess the use of these public dollars are being spent bringing the best value to the communities they serve. The traditional low bid procurement method for construction of an infrastructure project is one method of demonstrating value for money (VfM) to the public as it relies on competition to ensure the best price. P3 project delivery challenges the idea that value is totally defined by minimizing project cost. P3 projects permit public agencies to extend the value calculus beyond construction completion to the development, design, operations and maintenance phases of a project as well as to gain access to private finance to cover the gaps in public funding shortfalls. Quantifying VfM across a project's life cycle requires a much more robust assessment and doing so in a manner that is both fair and transparent to both the public and potential private industry partners demands a rigorous framework that combines the qualitative and quantitative evaluation in a manner that balances project risks between the agency and the P3 concessionaire. This research detailed in this thesis proposes just such a framework for agencies to assess whether or not P3 project delivery provides better Vfm than other available project delivery options.

CHAPTER 1
INTRODUCTION

Public-Private-Partnerships (P3s) have been used in the United States as far back as 1796 when Ebenezer Zane petitioned Congress with assistance with a project to extend a trail into the Ohio River Valley (Garvin 2008). World Bank (2013) defines P3s as "…medium to long term arrangements between the public and private sectors whereby some of the service obligation of the public sector are provided by the private sector, with clear agreement on shared objectives for delivery of public infrastructure and/or public services." P3s are again becoming a viable option for developing projects in the United States and many countries throughout the world. "Throughout the initial stages of the 21st century, the ingredients for expansion of the infrastructure (P3) market in the United States finally appeared to be coming together." (Garvin 2010) Some countries in Europe and Australia have already been implementing this alternative delivery method for funding of infrastructure projects. "Limited highway funds, unmet needs for new highway capacity, interest from private investors, and other factors have led to a substantial discussion of (P3) projects." (Brown 2009)

As government agencies explore the use of the P3 method of delivering mega-projects, there is virtually no research to provide guidance on determining if P3 delivery is an appropriate method for the given project. According to Burger and Hawkesworth (2011), "value for money…should be the driving force behind traditional infrastructure procurement…[and] undertaken only if it creates value for money…governments should prefer the method that creates the most value for money." Value for money is defined by Yescombe (2007) as "the combination of risk transfer, whole-life cost and service provided by the facility, as a basis for

deciding what offers the best value to the Public Authority." Public agencies need to evaluate if the public dollars are being spent the most efficient way possible, by getting the most value for their money. Private finance may not always be the least expensive option as debt service is not free, but the value gained through private innovation, transfer of risk, economies of scale, and the ability to build much needed infrastructure in the present time may be enough to offset, and sometimes outweigh, the cost of the debt service.

This thesis proposes a framework to identify the value for money in a P3 mega-project. The two overriding reasons why a public agency normally wants to enter into a long-term partnership with a private company are the ability to transfer risk from the public to the private sector and by providing better value for money to the public (Akintoye 2003). Preserving the public's interest and attracting private participation in highway P3 projects may seem like conflicting objectives. Balancing the two interests for P3 projects, requires that the public receives a reasonable price and obtains a marginal value or benefit. Likewise, private parties require a reasonable risk/reward profiles, and manageable transaction costs. "P3 arrangements are founded on the transfer of risk from the public to the private sector in circumstances where the private sector is best placed to manage the risk" Grimsey and Lewis (2004). Garvin (2010) states that the transition to a world where a nontrivial percentage of infrastructure services is provided by the private sector will eventually occur, transforming the role of Governments from service providers to overseers of service provision – i.e., 'steering versus rowing.'

Content Organization

This thesis consists of a compilation of three journal articles whose content and sequence was purposefully selected in accordance with the principal objective of the research mentioned above. Chapter 2 will summarize the literature, furnishing the reader the necessary background information to understand the results of the analysis and Chapter 3 will detail the methodology used to complete the research.

Chapter 4 describes the concept of Value for Money (VfM) and the processes used to compare VfM in P3 projects versus VfM in similar projects delivered using other project delivery methods. The paper presents a comparative analysis of VfM assessment practices in Virginia and against the VfM practice in use in New Zealand (NZ). Chapter 5 extends the findings detailed in the previous chapter to the question of project delivery method-specific VfM and compares the VfM attained by similar Design Build (DB) and P3 projects. Chapter 6 narrows the VfM focus to quantify specific P3 project risks found in the literature with the perceived value of each risk from the perspective of both the public and the private stakeholder and uses that output to populate the proposed P3 VfM framework.

The first article (Chapter 4) was submitted to the Transportation Research Board (TRB) and was accepted for presentation at the 2016 annual meeting. This article compared US and NZ approaches to P3 Vfm against the value received in traditional project delivery methods. The Virginia Office of Public Private Partnerships (VAP3) has a defined and documented process for comparing VfM between P3 and traditional project delivery both quantitatively and qualitatively. New Zealand Transport Agency (NZTA) also has a defined and documented process for

comparing VfM between delivery methods both quantitatively and qualitatively. The article identifies and discusses similarities and differences between the two countries VfM methods and summarizes the results.

The second article (Chapter 5) is ready to be submitted for publication. This article presents a detailed case study analysis comparing two different project delivery methods, P3 and DB, and how each achieved VfM and what the difference in VfM was from one to the other. The case study analyzes information gathered from two infrastructure mega-projects in the US, one in Missouri and one in Pennsylvania, with similar size and scope. The case study analysis provides a better insight to agencies on the additional value brought with involving the private sector in project finance and long-term maintenance.

Finally, the third article (Chapter 6) is also ready to be submitted for publication. It presents a study of the risks typically present in P3 projects and what importance of each risk with regard to VfM. Transfer of risk from the public to the private sector is a major benefit of P3 project delivery. This article provides insight into each risk's level of importance is to each stakeholder in a P3 project. The article provides a framework to assist agencies in finding a balanced (potentially optimal) risk allocation for each project to provide the necessary perceived VfM for each stakeholder that will facilitate achieving the overall best value for the taxpayer.

CHAPTER 2

BACKGROUND AND MOTIVATION

This chapter presents information that provides a better understanding of current Value for Money (VfM) practices used in procurement to evaluate project delivery methods, and some conclusions obtained from an analysis of this information. The content of this chapter is used to complement and support the journal articles comprised in Chapters 4, 5, and 6. Furthermore, this chapter describes the motivation behind the objective of this thesis, and the principal problem expected to be addressed with its completion.

Background

Yescombe (2007) found that the public-private-partnership (P3) concept originated in the United States to name joint public and private sector funding for education programs. In the 1950's, it began to be used to describe joint funding for utilities. P3 came into wider use in the 1960's public-private joint ventures to deliver urban renewal projects. "A P3 is thus an alternative to procurement of the facility by the public sector using funding from tax revenues or public borrowing. In a typical public sector procurement (also known as "design bid build"), the public authority sets out the specifications and design of the facility, calls for bids on the basis of this detailed design, and pays for construction of the facility by a private sector contractor. The Public Authority has to fund the full cost of construction, including any cost overruns, and operations and maintenance of the facility are entirely handled by the Public Authority, and the contractor takes no responsibility for long-term performance of the facility after the construction-warranty period has expired…In a P3, the Public authority specifies its requirements in terms of

'outputs', which set out the public services which the facility is intended to provide, but which do not specify how these are to be provided" (Yescombe 2007).

As Yescombe concisely described the difference in procurement methodology between design-bid-build (DBB) and P3, it is easy to see how this methodology gets away from the public authority prescribing the details of the design and specifications of a facility and to one where the public authority focuses more on the long-term outputs or performance of a facility and allows the private sector the ability to develop a plan to finance design build operate and maintain the facility to fulfill these desired outputs and performance requirements for an extended period of time. As Garvin (2010) so eloquently stated: "transforming the role of Governments from service providers to overseers of service provision – i.e., 'steering versus rowing.' P3s now become a vehicle for government agencies to transition from 'rowing to steering' as this method now allows governments' the ability to let the private sector perform the more arduous task of 'rowing' and can now focus more on 'steering' in the direction needed to ensure services and infrastructure are in place to support local economy and other needs of the public they serve.

Variations of P3

There are a number of distinct variations to P3 project delivery. The World Bank (2013) definition is: "medium to long term arrangements between the public and private sectors whereby some of the service obligation of the public sector are provided by the private sector, with clear agreement on shared objectives for delivery of public infrastructure and/or public services." This definition leaves open for many different interpretations, but Infrastructure Ontario, in a report by the Auditor General of Ontario (2014), defines five different types of what they call Alternate Finance Procurement (AFP) or referred to in the US as P3. In all five

variations the private sector provides finance of the activities for which it is contracted which can be; build and finance, design build and finance (DBF), build finance and maintain, design build finance and maintain (DBFM), and design build finance operate and maintain (DBFOM).

Table 2.1: Variations of P3 Project Delivery (adapted from Auditor General of Ontario 2014)

Design	Build	Finance	Operate	Maintain	Comments
	X	X			Smaller projects like renovations, additions or expansion of existing infrastructure.
X	X	X			Combine efficiencies of design-build (DB) with complete or partially deferment of finance.
	X	X		X	Provides long-term financing.
X	X	X		X	Large projects, new green field construction. Provides long-term financing.
X	X	X	X	X	Responsibilities for designing, building, financing and operating bundled and transferred to private sector. Partly or wholly financed by debt leveraging revenue streams

P3 Contract Structure vs Traditional Method

The contractual relationships differ greatly between P3 and traditional (DBB) project delivery. The Public Authority in the traditional method has a separate contract with the design firm and the construction contractor building the facility. The Public Authority may even have a separate contract with an operations and maintenance (O&M) contractor to perform O&M services over the lifetime of the project. Under a P3 agreement the Public Authority has a single agreement with a private concession company that contracts the debt service, design firm, construction contractor, and the long-term O&M contractor.

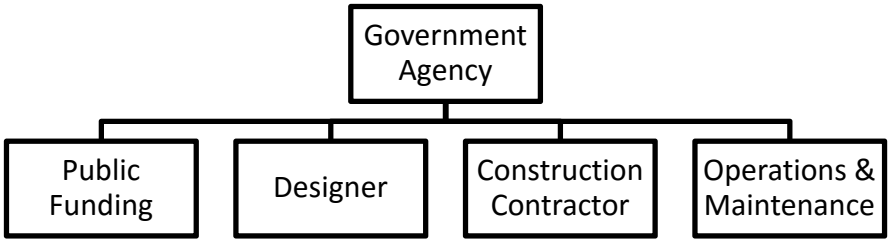

Figure 2.1: Traditional Project Delivery Method Relationships

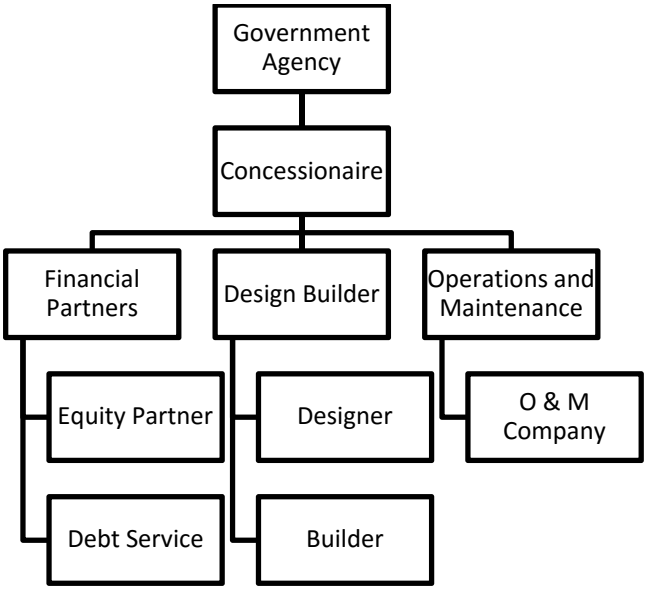

Figure 2.2: P3 Project Delivery Method Relationships

As shown in the above Figure 2.2, there is a single contractual agreement between the public and the private sector through the concessionaire or concession company. Most P3 projects incorporate the use of a DB firm that is contracted to perform all design and construction phases of the project. The DB firm is directly contracted to the concession company. In DBFM or DBFOM project delivery, there is a long-term operations and/or maintenance component. The concession company contracts directly with an operations and maintenance contractor for a duration of the project life cycle as specified by the public authority. There is also a finance arm

to the concession team, this comprises of the private finance component of the P3 agreement. The finance arm consists of equity partners and debt service providers. The equity partners are the long-term investors in the project for the overall contract duration with the public authority. Debt service providers are financial institutions that loan the concession team money for design and construction activities that is paid back by the concession team through incremental payments over the life of the project. Typically, the concession company is also a financial equity partner.

Value for Money

"Value for money is defined as the optimum combination of whole-of-life costs and quality of the good or service to meet the user's requirement. The term whole-of-life is used to refer to the life cycle of the good or service. VfM is not the choice of goods or services based on the lowest cost bid." (Moralles et al. 2009) Agencies must account for the costs and savings over the lifetime of the project when performing VfM assessments. VfM assessments are processes agencies utilize while comparing procurement of different project delivery methods. VfM assessments are typically a combination of quantitative and qualitative analysis to determine what delivery method will provide the most value for money for the project. "The purpose of Value for Money analysis is to inform governments' decision on whether to implement proposed projects as P3s, or through other more "traditional" forms of public procurement. To that end, Vfm analysis typically involves a combination of qualitative and quantitative analysis" World Bank (2013). The quantitative component includes all project factors that can be valued in monetary terms. Quantitative assessments typically rely on the use of a public sector comparator (PSC) to estimate the expected life cycle costs to the public agency if pursued using the traditional method. VAP3 uses a "shadow bid" as a P3 delivery method

comparison. The qualitative assessment takes into consideration the aspects of the project that are not quantifiable. "The methodology for carrying out a pre-procurement VfM analysis involves the following:

- Creating a PSC that estimates the risk-adjusted life-cycle costs and revenues from carrying out the project through a traditional approach;
- Estimating the risk-adjusted life-cycle costs and revenues of the P3 alternative-that is, a hypothetical shadow bid (SB);
- Completing an item-to-item comparison of the present values of costs and revenues under the two approaches." (DeCorla-Souza 2014)

The components included in most VfM quantitative assessments include the raw costs of design, construction, operations, and maintenance of the facility. These costs will be the same if delivered using P3 or the traditional method as they are as described, the raw costs it takes to perform each phase of the project life cycle without an adjustment to include risk. Competitive neutrality is another component included with the VfM assessment and is the "inherent competitive advantage or disadvantages that are available to a government agency pursuing the PSC but inaccessible to the private sector completing the P3" (Moralles et al. 2009). For example, the public sector is exempt from property, sales and income taxes, but the private sector is not. VfM assessment typically includes efficiencies in private sector design, construction, operations and maintenance if delivered as a P3. Private finance costs versus public finance costs must be compared during the VfM assessment as private debt service is not free and the costs for private entities to provide debt typically add additional cost to the P3 project. Finally, risks must be accounted for in the VfM quantitative assessment, both transferred and retained

risks. A value must be determined for each risk based on the monetary consequence and probability of occurrence. According to Moralles et al. (2009): "value of risk = consequence x probability of occurrence"

The Virginia DOT posits that to "deliver Value for Money, a candidate project needs to provide the lowest (or optimum) level of costs (adjusting for any differences in service quality and risks) over the whole asset life compared with procuring it using a traditional public sector project delivery method such as design-bid-build or Design-Build" (VAP3 2012). Figure 2.3 was adapted from VAP3's Value for Money Guidance Document and graphically depicts each of the components used for the VfM quantitative assessment.

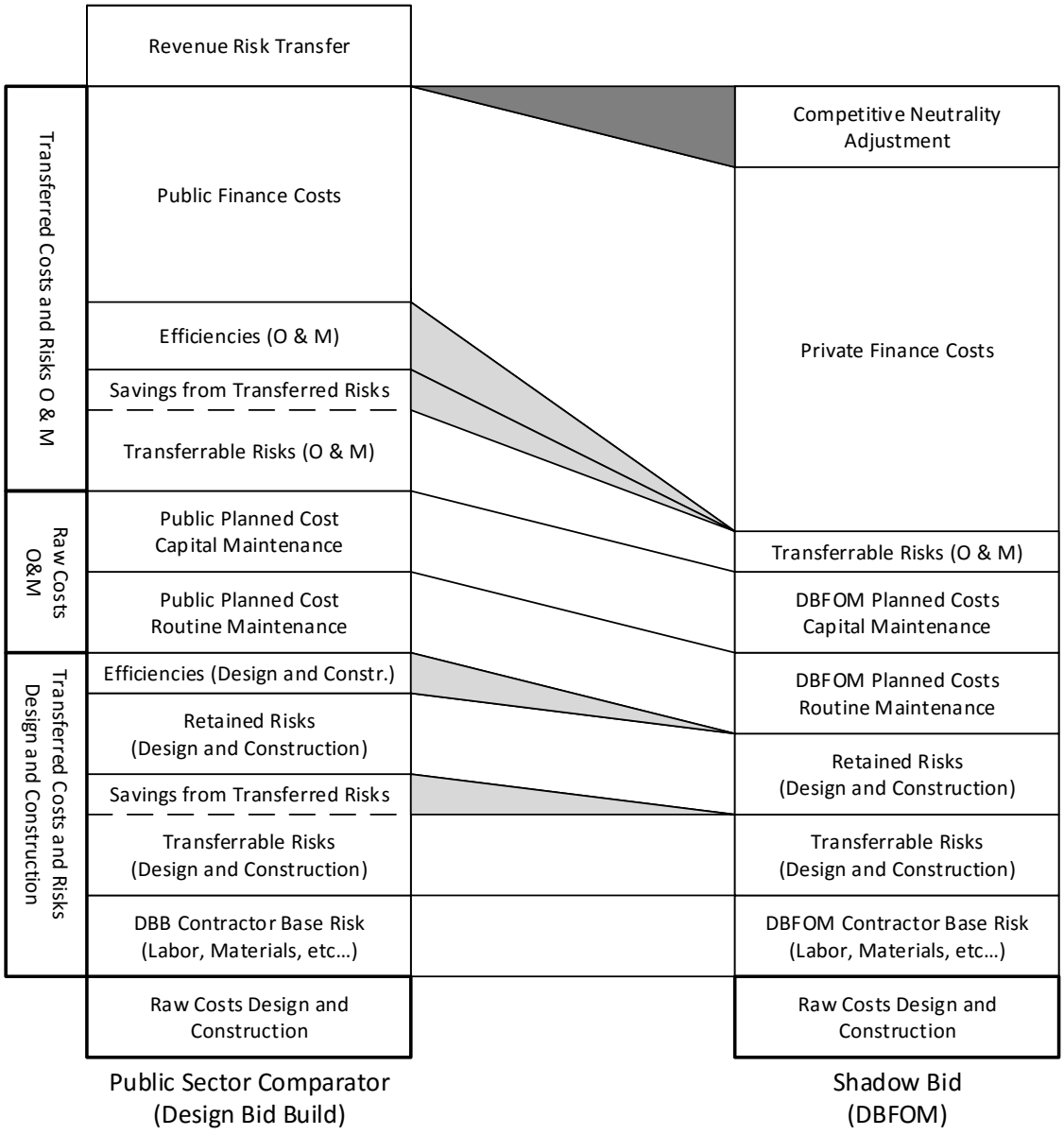

Figure 2.3: Components of the VfM quantitative assessment (adapted from VAP3 2012)

A qualitative assessment is performed in conjunction with the quantitative assessment to determine other factors that may not be able to be quantified in monetary terms. The VAP3 (2013) *Value for Money Guidance Document* states: "Unlike the quantitative assessment, the qualitative assessment is less prescriptive and varies depending on the project in question and

other factors. In general, the qualitative assessment will seek to identify factors which will influence the project in terms of:

- Viability – the ability to form a sound contract
- Performance – the opportunity to encourage risk sharing and innovation
- Achievability – the capability to the commonwealth and the private sector to deliver the project"

It is suggested to present the qualitative and quantitative assessment together in a standard reporting format. (VAP3 2012) Regardless of the contents of each assessment it is incumbent upon the agency "to strike the right balance between qualitative and quantitative approaches" (World Bank 2013).

Motivation

While conducting the preliminary literature review for this thesis, it was found there is virtually no research to provide guidance on determining if P3 project delivery is an appropriate method for the given project. Previous studies have compared the performance of DBB and DB projects using performance metrics such as budget and schedule performance, but there were no studies comparing the VfM between different project delivery methods. As previously cited from Akintoye (2003) the primary reasons a public agency would enter into a P3 agreement with the private sector are the ability to transfer risk from the public to the private sector and by providing better value for money to the public. "The purpose of Value for Money analysis is to inform governments' decision on whether to implement proposed projects as P3's, or through other more "traditional" forms of public procurement." (World Bank 2013)

Public agencies need to justify their selection of an alternative project delivery method over the traditional procurement method. Comparing P3 to the traditional procurement becomes more challenging due to the increased amount of scope and risks with increased complexity and longevity over the life cycle of the project. The issue is compounded by the fact there is very little field data available for US P3 projects due to the recent advent P3, "as public entities and private developers create new arrangements to deliver, operate and maintain transportation services, P3s in the U.S. continue to evolve" (FHWA 2016).

Determining the VfM across a complex infrastructure project's life cycle is more complex than simply comparing construction bid prices with award to the lowest bidder. Not only are there design, construction, operations, and maintenance costs to quantity and include, but there is also the value of private finance to evaluated P3 VfM versus traditional procurement VfM. The ability to build an infrastructure project now rather than waiting for public funds to become available may have some value to public agencies as a benefit to the public users of the infrastructure being supplied by the government agency. There is great value to the public agencies to have the ability to compare the overall benefits and costs of design, construction, finance, operations, and maintenance between different procurement methods to allow agencies to justify both the development for new infrastructure and the preferred procurement method of delivering the infrastructure project.

There is value to public agencies in having the ability to compare overall benefits and costs of design, construction, finance, operation, and maintenance of the infrastructure projects used to serve the communities. VfM assessment provides a rigorous rubric that allows public agencies

to compare and justify both the benefit of developing new infrastructure projects and the preferred delivery method for the infrastructure project. This research study seeks to answer the questions:

- What value can be applied to the transfer of risks in a P3 project?
- Can a project delivered as P3 provide better VfM?

The answers provide a framework that can be used for agencies while conducting VfM assessments on their projects.

Problem Statement

It is difficult for agencies to quantify the transfer of project risk, the benefits of DB efficiencies, the benefits of private finance, and the benefits of using the DB firm for long-term operations and maintenance. This research seeks to establish a framework for identifying VfM in a P3 project. Many agencies struggle to quantify the components of the VfM framework. If provided a tool, they can now assess the change in VfM if a project is delivered as a P3?

CHAPTER 3
RESEARCH METHODOLOGY AND VALIDATION

Chapter 3 presents an overall view of the methodology used in the research. The methodology sections of Chapters 4, 5, and 6 detail the specific research instruments that were applied to each journal paper's primary topic. There were four primary research instruments that were used to collect and evaluate the information used to eventually develop the proposed P3 VfM framework that is the product of the research. The research instruments are as follows:

- Literature review
- Content analysis
- Structured interviews
- Case studies

The details of each are described in the subsequent sections of this chapter.

Literature Review and Content Analysis

A comprehensive review of the literature on the topics that pertain to this research was conducted. The primary topical areas are as shown below:

- Alternative project delivery methods: This topic included papers, studies and reports on the full spectrum of project delivery starting with traditional DBB and extending through alliance contracts as practiced internationally. Particular attention was given to measuring integration, collaboration, and the contractual relationships between public agencies and private industry.

- VfM: The term "value for money" is more common in the international literature than in papers authored in the US. The term includes both qualitative and quantitative aspects, and the research specifically sought to find examples of how VfM is calculated.
- Finance and finance theory: P3 is defined by the presence of private financing for a public project.
- Risk and decision theory: Contracts are used by public agencies to allocate or shed the risks inherent to public construction projects. Specific attention was paid to literature that provided not only the public perspective of risks commonly found in P3 but also the private perspective.

Content analysis is a rigorous procedure that permits the researcher to infer meaning by the frequency with which given key words occur in a specific document (Weber 1985). Since P3 is a fairly recent project delivery method, the literature is not as rich as that found for other alternative project delivery methods, like DB. Therefore, it was determined that a formal content analysis was warranted on the literature itself to provide an understanding of the relative impact and frequency associated with the various risks that must be addressed during P3 project delivery. According to Hsieh and Shannon (2005) there are "three distinct approaches: conventional, directed, or summative… used to interpret meaning from the content of text data and, hence, adhere to the naturalistic paradigm."

The summative approach to content analysis was used to identify the common risks observed by previous authors in P3 projects as well as the cumulative frequency of appearance. The results were used to calculate the Frequency Index component of the Importance Index

(Assaf et. Al 2005), described in detail in Chapter 6. The Importance Index is an algorithm that assigns an order of importance based on a given parameter's impact on the outcome and the probability that the parameter will occur. Therefore, the summative content analysis approach was ideal for developing the necessary input data.

Case Study Methodology

A case study is an empirical study that allows the researcher to make a deeper inquiry into a given question than that provided by survey or analytical statistics. Additionally, it has become the preferred research instrument for topics dealing with business practices and legal/contractual questions, and "this research approach is especially appropriate in new topic areas (Eisenhardt 1989). Both P3 project delivery and VfM analysis qualify as "new topic areas" in the US context. Eisenhardt goes on to state that case study research produces a "resultant theory is often novel, testable, and empirically valid." Additionally, case study research is particularly applicable to addressing "how" and "why" questions when the researcher does not control the events associated with the research and when the focus is on understanding the real-life context (Yin 1994). Case studies give the researcher the ability to sample contextual conditions that may be very pertinent to the analysis. In public procurement research, collecting case studies using participant interviews allows the researcher to investigate the rationale behind key events that project performance outcomes (Harris and Brown 2010). As a result, case study research permits a context to be defined to a finer level of granularity that common analytical/statistical research instruments.

Structured Interviews

As mentioned above the coupling of case study research with structured interview techniques creates an environment that encourages dialog and allows both the interviewee and the interviewer to digress as required to reach a meeting of the minds. This approach requires the researcher to first ensure that the question being asked was fully understood by the interviewee and before recording the answer, the protocol requires the interviewer to read back the answer to the interviewee and make sure that no misunderstanding has taken place. The structured interview questionnaire was developed on lines similar to the methodology prescribed by the US Department of Education (DOE) (ERIC/AE 1997). The DOE methodology is prescribed for use when the researcher needs to "spend considerable time probing participant responses, encouraging them to provide detail and clarification" (Harris and Brown 2010). The structured interview is best used when "information must be obtained from program participants or members of a comparison group… or when essentially the same information must be obtained from numerous people for a multiple case-study evaluation" (GAO 1991). Since both of these conditions apply to the problem at hand, the instrument is the appropriate tool for this research.

Research Methodology Plan

Figure 3.1 is a flow chart that shows the plan used to conduct the research reported in this thesis. It shows that the plan was divided into three stages.

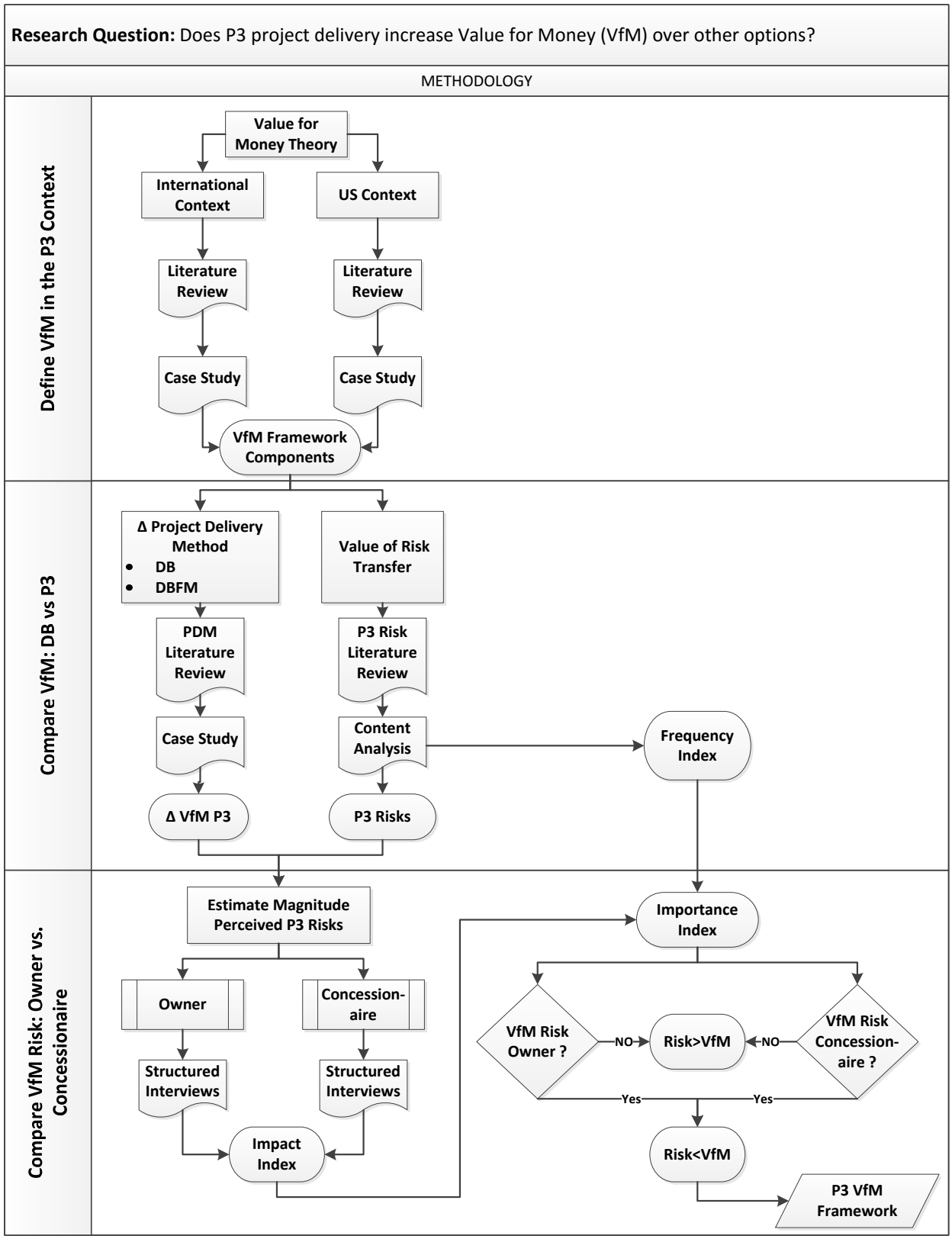

Figure 3.1: Research Methodology

First, a series of actions were taken to define and understand VfM in the public P3 infrastructure project context. The outcome was a comparison of US and international approaches to both VfM and P3 using literature review and case studies. At this stage, the VfM program as used by the New Zealand Transport Agency (NZTA) was compared to the VAP3's VfM program. In both cases, on-site face-to-face interviews were completed to ensure that the researcher fully understood the content of each document.

The second stage compared the design-build-finance-maintain (DBFM) version of P3 to a purely DB project of similar scope, complexity and magnitude. The outcome was the quantification of the VfM to the public agency derived by assigning the financing and maintenance to the private sector concessionaire. As will be seen in Chapter 5, the researchers were blessed with the unique opportunity to have both DB and P3 projects that delivered 500+ rural bridges. Thus eliminating the need to make adjustments for scale and type between the two projects.

Lastly, a comprehensive analysis of perceived risk was conducted from both the agency and concessionaire's perspectives. This stage tested the hypothesis that both the public and private stakeholders would have similar perspectives of the risk profiles. The idea here is that for a project to be successfully delivered using P3, both the owner and the concessionaire must be able to identify and communicate VfM to their respective external stakeholders. This stage pulled results from the previous two and synthesized them into the proposed P3 VfM framework presented in Chapter 6.

Validation

Validation of the proposed framework is shown in Table 3.1. As required, construct, internal and external validation was performed. As can be seen in the table, the content analysis of relevant literature was used to furnish construct validation. Internal and external validation was completed by providing the framework to both owner and concessionaire personnel and essentially asking them to review and comment on it. The internal validation was conducted by the same participants that provided the Stage 2 structured interviews about the PennDOT P3 project. External validation was received by showing the framework to a member of the VAP3 Department and a member of a multinational P3 concessionaire that was not a member of the PennDOT project team. In all cases, feedback was positive and therefore, the framework was found to be valid.

Table 3.1 Validation Plan Outcomes

Construct Validation	Internal Validation	External Validation
P3 Literature: Yescombe 2007, Buxbaum and Ortiz 2009, Gransberg et. al 2015,	DOT response: It contains components of economies of scale cost savings and risk transfer. "Has to be reasonable and has to be a good deal for both parties."	DOT response: This is similar to the approach we use. "Costs are big things, we spend a lot of time estimating design build costs and long-term maintenance costs. Try to quantify and assign risks, both transferred and retained risks...use Monte Carlo simulation."
VfM Literature: DeCorla-Souza 2014, VAP3 2012, NUI 2009, Moralles et al. 2009		
Finance Literature: Weaver and Weston 2008, Grimsey and Lewis 2004	Concessionaire's response: I agree with the concept. "Do not give the private sector a risk they cannot control."	Concessionaire's response: "I think this is really good. I really like his approach."
Risk Literature: Akintoye et al. 2003, Bing et. al 2004, Grimsey and Lewis 2005, Ke et. al 2009		

To summarize, the research made use of four research instruments, ranging from a typical literature review to the development of formal case studies. An emphasis was placed on collecting empirical "why" and "how" information on the case study projects under investigation. The research followed a rigor protocol and utilized tools like the Importance Index

(Assaf et al. 2005) to eliminate personal bias from the analysis. Hence the next chapter will provide the details of the first stage of the thesis research.

CHAPTER 4
VALUE FOR MONEY ON A PUBLIC PRIVATE PARTNERSHIP INFRASTRUCTURE PROJECT: AN INTERNATIONAL COMPARATIVE ANALYSIS

Barutha, P. and Scheepbouwer, E.. (2016). Value for Money on a Public Private Partnership Infrastructure Project: An International Comparative Analysis. *Transportation Research Board: 2016 Annual Meeting Compendium of Papers.* Paper No. 16-3226

This chapter presents a detailed description of VfM assessment used in evaluation of a public private partnership project. This was an international comparison study of VfM assessment practices in the US (Virginia Office of Public Private Partnerships) and New Zealand (New Zealand Transport Agency). The conference paper contained in this chapter define VfM assessment framework that was used as the basis for the next two articles presented in Chapter 5 and 6.

Abstract

As the need to repair and improve the existing public infrastructure (roads, bridges, and water systems) has increased in recent years, so has the need to find additional funds to finance these projects. Many public agencies are turning to private finance to help develop their infrastructure projects. This is not a new delivery method in the United States or internationally, but one that is becoming increasingly popular in recent years. The report will describe how public agencies in the US and internationally (NZ) are currently evaluating how to determine whether a project should be delivered through a Public Private Partnership by use of a Value for Money Analysis. Public agencies need to evaluate if the public dollars are being spent the most efficient way possible, by getting the most value for their money. Private finance may not always be the least expensive option as debt service is not free, but the value gained through private

involvement and economies of scale may be enough to offset, and sometimes outweigh, the cost of the debt service. This research will describe the evaluation process public agencies are using today and report on a model a public agency could use as an evaluation tool while analyzing if private finance is a good option for their project. This will be a comparative study of two different public agencies from two different countries, Virginia Office of Public Private Partnerships (VAP3) and the New Zealand Transport Authority (NZTA).

Introduction

"The UK treasury defines Value for Money (VfM) as the optimum combination of life-cycle costs and quality of a good or service to meet the user's requirements as opposed to the lowest responsible cost that could be paid for that good or service" and DeCorla-Souza (2014) goes on to state "Analyzing VfM quantitatively involves comparing the financial impacts of different project procurement alternatives." This involves comparing estimated project costs to the public of delivering the project with the estimated cost of delivering the same project to the identical specifications using a P3 delivery model (Auditor General of Ontario 2014). "The purpose of VfM analysis is to inform governments' decision on whether to implement proposed projects as Public-Private-Partnerships (P3s), or through other more "traditional" forms of public procurement. Typically the VfM analysis involves a combination of qualitative and quantitative items (World Bank 2013).

P3s have been used in the United States as far back as 1796 when Ebenezer Zane petitioned Congress with assistance with a project to extend a trail into the Ohio River Valley (Garvin 2008). Some countries in Europe and Australia are nowadays implementing this

alternative delivery method for funding of infrastructure projects. And also in the US, limited public funds, increasing needs for new highways coupled with interest from the private sector have led to a substantial discussion of P3 projects (Brown 2009). After some absence, it seems that P3s are again becoming an accepted option for developing projects.

Public agencies need to evaluate if the public dollars are being spent the most efficient way possible, by getting the most value for their money. Agencies use a variety of evaluation tools to justify and communicate the rationale used in determining how a project will be delivered. Virginia Office of Public Private Partnerships (VAP3) and New Zealand Transport Agency (NZTA) use a similar but different VfM analysis to determine if a project will be delivered using a P3. How the risk is allocated and transferred from the public to the private sector and how agencies account for uncertainties such as quantifying the time value of money are examples of some of the elements of the process that may affect the result of the VfM analysis. This paper evaluates the process of determining if a P3 project brings the most value for the public used by two different agencies in the US and NZ and analyzes the differences.

Literature Review: Public Private Partnerships and Value for Money

"P3s are typically medium to long term arrangements between the public and private sectors whereby some of the service obligation of the public sector are provided by the private sector, with clear agreement on shared objectives for delivery of public infrastructure and/or public services." (World Bank 2013) P3s can be characterized by a long-term contract between a public- and a private-sector party that involves design, construction, financing, and operation of a public infrastructure facility by the private-sector party. Payments over the life of contract to the private-sector party for the use of the facility, are made either by the public-sector party or by the

general public as users of the facility. At the end of the contract term the facility can remain in public-sector ownership, or revert to public-sector ownership (Yescombe 2007).

For development of capital improvement projects, there are different delivery methods of P3s that can be used for the project. Ontario Infrastructure (Auditor General of Ontario 2014) defines five different types of Alternate Finance Procurement (AFP) or P3 projects. In all five the private sector provides the finance of the activities for which it is contracted, which can be build (and finance), design and build, build and maintain, design build and maintain or design build maintain and operate (Table 4.1).

Table 4.1: Overview of P3 varieties (Adapted from Auditor General of Ontario 2014)

Design	Build	Finance	Operate	Maintain	Comments
	X	X			Smaller projects like renovations, additions or expansion of existing infrastructure.
X	X	X			Combine efficiencies of design-build (DB) with complete or partially deferment of finance.
	X	X		X	Provides long-term financing.
X	X	X		X	Large projects, new green field construction. Provides long-term financing.
X	X	X	X	X	Responsibilities for designing, building, financing and operating bundled and transferred to private sector. Partly or wholly financed by debt leveraging revenue streams

Before the choice for a particular type of P3 procurement is made, the public agency needs to establish why it wants to enter into a financial partnership with a private company. The two overriding reasons why a public agency normally wants to enter into a long-term partnership with a private company are the ability to transfer risks from the public to the private sector and

by providing better value for money to the public. A public entity must therefore answer the two key questions:

1. Does the partnership have a genuine transfer of risk from the public to the private sector?
2. Does the partnership provide true VfM for the public sector?

An example of genuine transfer of risk would be the transfer of demand risk from the public to the private sector. This occurs when a toll road is developed by private industry for use by the public and the revenue of the toll road is used as compensation for this development. The demand risk of the toll road resides with the private developer. An example of true VfM can be found in efficiencies the private sector brings to the project to save the public money like economies of scale. Pennsylvania Department of Transportation (PennDot) provides an example of this by packaging 558 bridges together into one proposal to one private developer instead of 558 separate proposals by 558 different private contractors. PennDot is able to bring value for money to the project by reducing procurement costs and saving money with reduced construction costs.

Appropriate risk allocation between the public and private sector is the key to achieving VfM. The private sector can accept responsibility for a risk that is within their control, ask an economically appropriate price. For acceptance of a risk which the private sector cannot manage, they will seek to charge a premium, thereby reducing value for money (National Audit Office 1999). The overriding aim of risk allocation is find a sensible balance between risk transfer and value for money. (Akintoye 2003)

Garvin (2010) states that the transition to a world where a nontrivial percentage of infrastructure services is provided by the private sector will eventually occur, transforming the role of Governments from service providers to overseers of service provision – i.e., 'steering versus rowing.' Preserving the public's interest and attract private participation in highway P3 programs may seem like conflicting objectives. Balancing the two interests for P3 projects, requires that the public receives a reasonable price and obtains a marginal value or benefit. Likewise, private parties require reasonable risk/reward profiles, and manageable transaction costs. "Value for Money is the combination of risk transfer, whole-life cost and service provided by the facility, as a basis for deciding what offers the best value to the Public Authority." (Yescombe 2007)

Case Study: Virginia Office of Public Private Partnerships

Some government agencies have developed VfM processes to determine if a project has VfM if delivered as a P3. VAP3 has developed a detailed process that is used to compare both the financial impacts and the risk impacts of procurement alternatives for a project. The VAP3 has published a "PPTA Value for Money Guidance" document (VAP3 2012). This document states, "The procurement of a PPTA (P3) project represents value for money when – relative to a traditional project delivery method – it delivers the optimum combination of net life cycle costs and quality that will meet the objectives of the project and the commonwealth." The VAP3 also published a "PPTA Risk Analysis Guidance" document (VAP3 2012). One of the objectives of the document is to "enhance the understanding of the relationship between risk analysis and value for money in the context of developing successful PPTA projects."

As demonstrated by the two documents, the VAP3 has defined a process to strike the balance between risk transfer and value for money, which has been described as the overriding aim of risk allocation under private finance projects (Akintoye 2003). The VAP3 (2012) defines delivering Value for Money, "a candidate PPTA project needs to provide the lowest (or optimum) level of costs (adjusting for any differences in service quality and risks) over the whole asset life compared with procuring it using a traditional public sector project delivery method such as Design-Bid-Build or a Design-Build." This definition emphasizes that the assessment process is comparative. The assessment must address financial and wider benefits to the Agency through a combination of lower net life cycle costs and higher service quality. "The Agency needs to take into account the service quality which is required and the ability of the private sector to deliver the project objectives, with a selection process that yields a best value proposal which has been evaluated for both service quality and price."

The VfM process is able "to eliminate low VfM candidate P3 projects early in the process, these

- may not have the necessary potential for innovation;
- may not be capable of generating private sector efficiencies;
- may not provide the opportunity for the private sector to influence service levels, and/or
- are not supported by a rigorous business case." (VAP3 2012)

VAP3 uses a Public Sector Comparator (PSC) to compare a P3 to a Shadow Bid. The PSC is defined as a theoretical measurement of the cost of public procurement of a facility, it estimates the risk adjusted whole-life cost of carrying out the project through a traditional approach, i.e.

Design-Bid-Build. The Shadow Bid is defined as if the Agency was to engage a P3 concessionaire, through a comprehensive agreement, for the engineering, design, construction, operation and/or maintenance of a project, including its financing, how much would the project be worth to the concessionaire today?

The objective of the initial VfM assessment is to provide an indication whether a candidate project is likely to represent value for money when compared with traditional delivery. The quantitative analysis is based on financial models that inputs various cost and revenue components into cash flows. The following cash flow components are included:

- Procurement Costs;
- Oversight and administration Costs;
- Design engineering costs;
- Construction costs;
- Operating Costs;
- Routine Maintenance Costs;
- Capital Maintenance Costs;
- Finance Costs;
- Contingencies;
- Transferrable Risks;
- Retained Risks;
- Revenues (if the project involves collection of user fees);
- Taxation assumptions; and
- Efficiencies and innovation (Shadow Bid only)

Each of the cash flows needs to be estimated and presented in separate cost and revenue lines profiled over the whole term of the proposed agreement to be input into the financial model for the PSC and the Shadow Bid. When the financial model is completed, the Cash Flows are then converted to present values included with the VfM analysis. An appropriate discount rate is used to perform the present value conversion. There is a separate process for selecting an appropriate discount rate. "The Discount Rate used in a VfM assessment should reflect the risks associated with it." (VAP3 2012) "Two generally accepted methods of developing Discount Rates commonly used for toll road projects include:

- Market comparable approach – this approach relies on the equity internal rate of return observed in precedent market transactions as indicative for the purposes of setting an appropriate rate of return for the current project analysis.
- Use of the Capital Asset Pricing Model (CAPM): the capital asset pricing model (CAPM) is a commonly used tool to estimate the cost of capital associated with a particular project. CAPM is a technical approach that uses a number of input variables and market statistics from a representative group of comparable publicly traded companies to assist in assessing the Discount Rate that may be applied to a target project."

"A CAPM based approach uses the concept that investors in a project/security must be compensated in two ways: the time value of money and risk." (VAP3 2012) "For preliminary analysis it may be appropriate to use a market comparable approach to develop an initial estimate of the Discount Rate. This may then be supported by a more detailed assessment of the Discount

Rate using a CAPM approach at the Final VfM Assessment stage when there is more information regarding the project inputs and risk profile."

"Although the quantitative assessment constitutes a significant portion of the VfM analysis, it is not the sole factor driving the VfM of a project. While many factors can be expressed in quantitative terms, others can only be expressed in qualitative terms. Therefore, it is important to identify those issues that might impact the VfM assessment but which cannot be expressed in monetary terms." (VAP3 2012) "In general, the qualitative assessment will seek to identify factors which will influence the project in terms of:

- Viability – the ability to form a sound contract;
- Performance – the opportunity to encourage risk sharing and innovation; and
- Achievability – the capability of the commonwealth and the private sector to deliver the project."

Virginia VAP3 provides "some examples of qualitative factors that should be addressed include:

- An assessment of the strategic fit of the PPTA project with the commonwealth's and Agency's overall objectives;
- Any concerns the Agency has about the deliverability of the project under a Comprehensive Agreement with the private sector. These may include whether the contract adequately describes the service requirements in clear, objective, output-based terms maintains sufficient operational flexibility over the lifetime of the contract at an acceptable cost;

- Whether the Agency is aware of any significant changes to project scope, specifications or maintenance requirements that may need to be included as change orders;
- Any differences in the specifications and service expectations between the PSC and Shadow Bid;
- Whether there are any equity, efficiency or accountability issues;
- Whether there are any regulatory or legal restrictions;
- Whether there are any affordability issues;
- Whether there are sufficient opportunities for the private sector to deliver high service quality through innovation;
- Whether there are sufficient resources in the Agency to manage the procurement process and administer the contract;
- The likely strength of competition in the market between private sector entities that submit proposals; and
- The robustness of the information used in developing the PSC."

"A decision to proceed as a candidate PPTA project depends upon both quantitative and qualitative VfM assessments. Where quantitative assessment of the Shadow Bid demonstrates a more favorable outcome than the PSC and qualitative factors also support the PPTA route, this would provide a valid case for advancing with PPTA procurement." (VAP3 2012) A final VfM assessment is performed as part of the procurement process. This assessment is performed after proposals have been received from the private sector and an "Apparent Best Value Proposal,

providing the optimum combination of financial benefit and technical quality, has been identified."

As demonstrated by the detailed, thorough, and comprehensive procedure, the VAP3 has defined a process to strike the balance between risk transfer and value for money, (Akintoye 2003) as the overriding aim of risk allocation under private finance projects. While performing a VfM analysis, VAP3 stated that there is much effort and focus on quantifying the design build costs and forecasting operations and maintenance costs and the risks associated with these costs. The risks are constantly assessed throughout the process. In a public private partnership arrangement, the private sector would own the risk of the design build costs and the operations and maintenance costs, thus the public sector having the ability to transfer these major risk costs to the private sector. By transferring these risks, the public sector is gaining value.

The comparison of the tangible costs, like construction, financing, legal services, engineering services, and project management services and forecasted maintenance costs versus the risks associated with these costs is illustrated in the report of the Auditor General of Ontario (2014). Infrastructure Ontario was able to quantify the value brought to the public through the transfer of the tangible costs to the private sector for 74 infrastructure projects. These costs were estimated to be nearly $8 billion higher than they were estimated to be if the projects were contracted out and managed by the public sector. However it valued the cost of the risks under public sector delivery to be $18.6 billion and the risk under P3 delivery to be $4 billion.

This $8 billion difference in higher tangible costs was more than offset by the estimate of the cost of the risks associated with the public sector directly contracting out and managing the construction and, in some cases, the maintenance of these 74 facilities (Auditor General of Ontario 2014). The estimated risks of having projects not being delivered on time and on budget were about five times higher if the public sector directly managed these projects versus having the private sector manage the projects.

Overall, the VAP3 case study has demonstrated how a VfM analysis can be used effectively to inform their decision whether to implement a prospective infrastructure project as a public private partnership, or to use a more traditional delivery method. This process uses a combination of both a quantitative and qualitative assessment to inform this decision. This process allows for a transparent, systematic approach of comparing different delivery method options for development of public infrastructure projects to ensure the public they are governing is obtaining the best possible value for their money on the project.

Case Study: New Zealand Transport Authority – Transmission Gully Project

Transmission Gully is a transportation infrastructure project consisting of a 27 kilometer four lane motorway located on the north island of New Zealand in close proximity to the country's capital city of Wellington. "[Transmission Gully] will be the first state highway project in this country [NZ] to be built as a public private partnership." (Forbes 2015) The project will cost $850 million NZ, which the government will pay off through availability payments over 25 years starting in the year 2020. A VfM assessment was performed prior to project procurement with the results and recommendations summarized in a report to the cabinet for approval titled "Enabling the Procurement of Transmission Gully Using a Public Private Partnership." (Office

of the Minister of Finance 2012) The assessment was performed by members of the NZ Treasury's Public Private Partnership team along with external advisors from a private organization. "The potential of Public Private Partnerships is assessed on a case-by-case basis." (Office of the Minister of Finance 2012)

"The long-term nature of P3 contracts, the fact that these contracts are usually used for large and often complex projects which individual government agencies will engage in only infrequently, the importance of financing arrangements and the typically large bidding and contracting costs make it desirable to develop specialist expertise to support departments and agencies in the development of P3's. In New Zealand, this role is played by the National Infrastructure Unit of the Treasury." The National Infrastructure Unit of the Treasury (NIU) has issued a "Guidance for Public Private Partnerships (P3s) in New Zealand" (NIU 2009) to outline for government agencies, potential bidders and the public, the general direction and principles that will be adopted, the processes that are to be followed and the rationale for them. It also provides a framework for assessing whether a P3 is to be preferred over other forms of procurement in any given situation.

The NIU is the governing authority overseeing the evaluation of P3 projects in New Zealand. NIU has set out a framework for evaluating whether a P3 offers value for money relative to a Design and Build contract by use of a comparator. NIU has identified the following pros and cons of delivering a project as a P3.

Table 4.2 shows the items that are to be calculated in dollars to add all benefits of using P3. The NIU states that it may be difficult or impossible to assign correct dollar values to all the elements, but it is still useful in the cost-benefit analysis of P3s. But in weighing up the pros and cons, dollar terms also give approximate relative weightings. The public sector comparator (PSC) is a measure of the cost of a project if delivered using traditional procurement methods. The PSC ensures that all the project risks have been identified and costed, that the project go/no-go decisions are made on the best possible information, and that bids are evaluated against a common benchmark (NIU 2009).

In the case study the PSC is the estimated cost if the Transmission Gully project were to be designed, built, financed and operated by the NZTA and consisted of

- 'Raw' Costs – All capital and operating costs associated with designing, building, maintaining and financing the P3.
- Competitive neutrality – A tax adjustment to allow for like-for-like comparison to account the additional cost of private sector finance.
- Transferred risks – Value for any additional costs of risks that would be transferred to the private sector partner under a P3 (Office of the Minister of Finance 2012).

Table 4.2: Project items that are calculated to dollar amounts and added to show the Pros and Cons of using P3 for a project in New Zealand (NUI 2009).

	Value for Money Analysis	Likely benefit of using P3 over alternative in dollars
Pros	Whole of life cost savings – i.e., the combination of construction and ongoing operating and maintenance costs	$XX,XXX
	Financing cost savings (during construction)	$XX,XXX
	Greater user benefits	$XX,XXX
	Likely to access additional revenue sources – creative ideas for extracting more value from the infrastructure, e.g., property development or advertising, etc.	$XX,XXX
	Greater cost certainty and therefore better decision-making by the public sector	$XX,XXX
	Greater community benefits – i.e., works undertaken for the benefit of the surrounding community	$XX,XXX
Cons	Tendering and contracting costs	$XX,XXX
	Cost of contract variations – i.e., the additional cost of changing contractual provisions above and beyond what it would cost if change was negotiated competitively	$XX,XXX
	Contract enforcement – difficulties with contract enforcement and specification of performance dimensions	$XX,XXX
Net value-for-money of P3s of conventional procurement:		$XXX,XXX

One of the key premises of undertaking P3 procurement is that it must offer greater value for money than conventional procurement approaches when both quantitative and qualitative dimensions of value for money are considered. While the cost of capital for the private sector is higher than for the government, this higher capital cost can be offset through private sector innovation and efficiencies in project costs like design, construction, operation and risk management, particularly where these are bundled together in one contract (NUI 2009). This premise was found to be the case for the Transmission Gully project. The benefits of procuring the Transmission Gully project through a Public Private Partnership were found to be that "There is reasonable probability that a private sector consortium will be able to beat the estimated cost of the Public Sector Comparator through innovative design and operation, and more effective

risk management. There are likely to be further benefits to the NZTA, and other road controlling authorities, from applying learnings from the P3, such as new solutions and approaches (including to risk management), to the wider network." (Office of the Minister of Finance 2012) The discount rate used for the analysis is determined periodically by the NZ Treasury for the different public sectors. The Transmission Gully Project used a discount rate of 6%. However when comparing the bids in the competitive tender with the PSC, it is important to ensure that the same discount rate is used for both. If the bidders' cost of capital is known, then that is probably a better discount rate for this purpose than the general government discount rate set out in Treasury guidance. (NUI 2009)

Comparison Case studies

VAP3 and NZTA both have a defined process they follow while determining if a prospective infrastructure project should be delivered as a public private partnership. A VfM Analysis is a component of both processes. The VAP3 and NZTA processes have many similarities but also have some key differences in process with respect to each other. The similarities for the VfM process include a quantitative and qualitative assessment, the use of a risk based public sector comparator, and the project development process framework. The VAP3 and NZTA use a quantitative and qualitative assessment both called a Value for Money Analysis. A risk based public sector comparator (PSC) is used by both agencies to compare a traditional delivery method such as design bid build (DBB) to a P3 delivery method. The P3 is labeled in Virginia as a shadow bid and with NZTA as a proxy bid model (PBM). The overall project development process framework is similar between VAP3 and NZTA and so is the time when the VfM analysis is performed in the process framework. The project development process framework includes 4 to 5 decision points by an appointed steering committee in

Virginia, while in New Zealand the process includes 4 gateway reviews by 6 independent experts. The VfM analysis takes place between the second and third decision/review point for both VAP3 and NZTA. Table 4.3 depicts the similarities and differences between VAP3 and NZTA VfM processes.

Table 4.3: Similarities and differences between Virginia DOT (VAP3) and the New Zealand Transport Agency (NZTA) VfM processes.

Similarities:	VAP3	NZTA
Quantitative and Qualitative Assessment	VfM Analysis	VfM Analysis
Risk Based Public Sector Comparator	Shadow Bid	Proxy Bid Model
Project Development Process Framework	4-5 Decision Points by Steering Committee	4 Gateway Reviews by 6 Independent Experts
Differences:	VAP3	NZTA
Process Document Governing Entity	State of Virginia	NZ Treasury
Transfer of Demand Risk	Yes	No
Discount Rate Determination	CAPM	Fixed Rate by NZ Treasury
Project Specific Variations:	VAP3	NZTA
Risk Identification and Quantification	Risk Assessment Guide	Varies
Repayment Time	Agreements up to 85 years	1 Agreement = 25 years
Funding Source	Varies	NZ Crown

The VfM process differences between VAP3 and NZTA are the entity that governs the VfM process document, the transfer of demand risk, and determining the discount rate. The State of Virginia governs the VfM process document while the National Infrastructure Unit of the Treasury governs the process document in New Zealand, the key difference being a State governed program in Virginia versus a nationally governed program in New Zealand. Demand risk, or in the case of the two case study projects, toll revenue risk is handled differently between agencies. VAP3 will transfer the demand risk if it brings the project the most VfM, but NZTA's

model will not transfer the demand risk. NZTA uses set availability payments to the private concession group for an agreed to number of years as the primary repayment mechanism, while VAP3 may employ tolls on the road users as a source of revenue and repayment for the private concession group. Lastly, how the discount rate is determined varies between VAP3 and NZTA. NZTA uses a set discount rate provided by the NZ Treasury for all infrastructure projects in the country, while VAP3 uses a more project specific way of determining a discount rate through the use of the Capital Asset Pricing Model (CAPM). CAPM as defined by Infrastructure Australia (Infrastructure Australia 2008) is "an economic model for valuing stocks by relating Systematic Risk and expected return. Based on the idea that investors demand additional expected return (called the risk premium) if asked to accept additional risk."

Figure 4.3 illustrates the quantitative comparison of the different cost components of the PSC and the Shadow Bid. NZTA uses a similar methodology when comparing delivery methods. On the left are the public sector comparator costs and the right represents the shadow bid costs. The highlighted gray areas represent differences between the PSC and the shadow bid. The top gray area represents the competitive neutrality adjustment needed for the shadow bid. The other two gray areas represent the private sector cost saving efficiencies of both the design and construction phase and the O&M phase of the project which have to be added to the PSC if the public delivers the project using a traditional delivery method. The savings from efficiency of transferred risks represents the private sector's ability to more efficiently manage the risks present during the design and construction phase and the operations and maintenance phase. Finally, the figure depicts a difference between the VAP3 and the NZTA VfM models, VAP3

may transfer the revenue risk to the private sector and the NZTA model does not transfer this risk. Both agencies account for competitive neutrality adjustments.

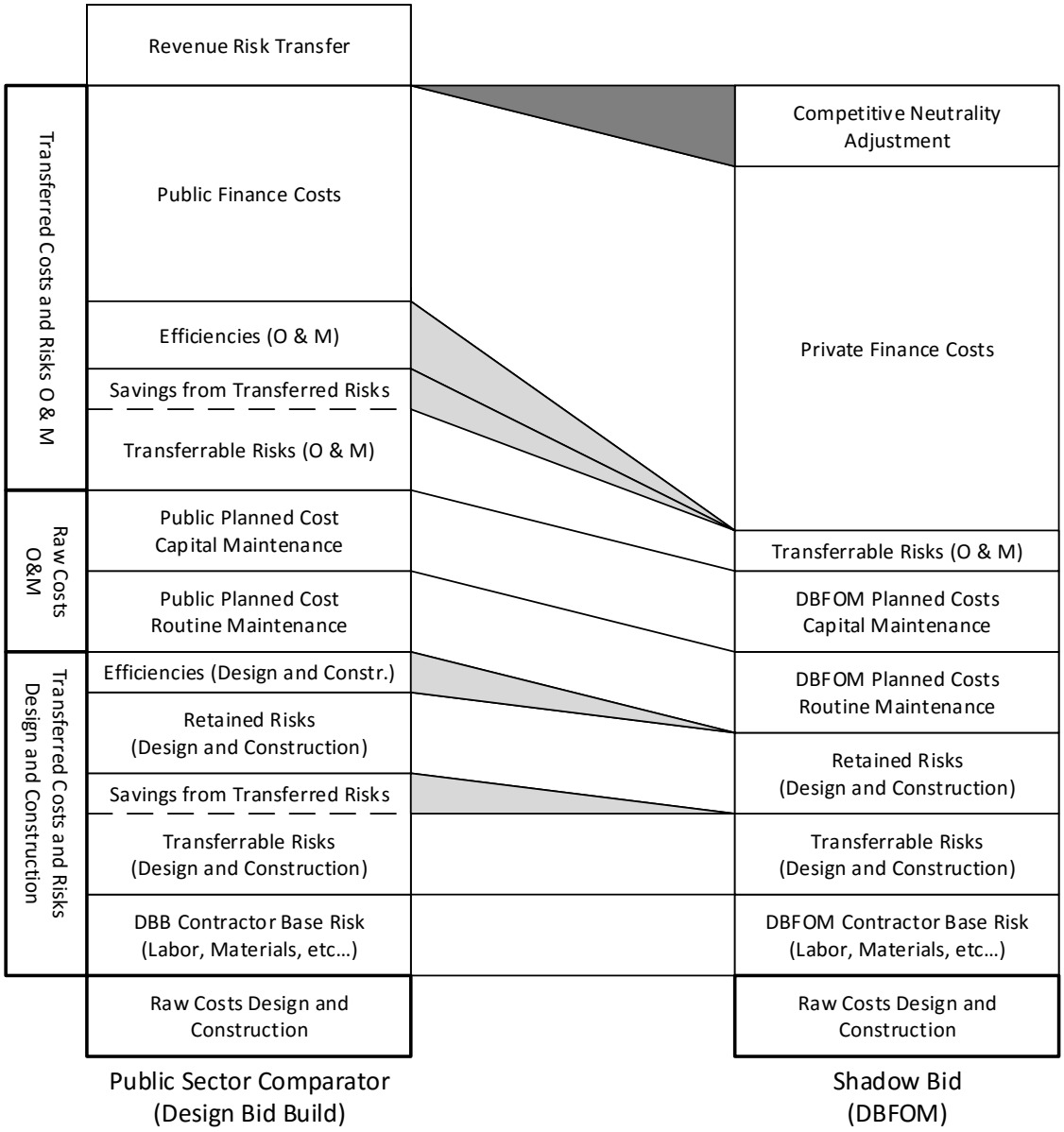

Figure 4.3: VfM Comparison between PSC and Shadow Bid (Adapted from VAP3 2012)

Conclusions and Recommendations

The key points for the public agency while evaluating if a project should be delivered a public private partnership are 1) is there genuine transfer of risk from the public sector to the private sector and 2) is there true value for money to the public sector. VAP3 and NZTA use a Value for Money Analysis as an evaluation tool to determine if a project should be delivered as a public private partnership. The VfM process for both agencies contain quantitative and qualitative analysis evaluating the risk transfer and value for money to the public sector. This enables both transportation agencies the ability to equally compare a public private partnership project delivery to a more traditional project delivery method.

Comparing the different agencies' processes for determining project VfM has shown there are similarities within the process and a few differences. Similarities include:

- Quantitative and Qualitative Assessment
- Use of a Risk Based Public Sector Comparator
- Project Development Process Framework and when the VFM occurs within the development process

Differences in the Agencies' Process include:

- Transfer of Demand Risk to private sector
- Governing Body Process Document
- Discount Rate Determination

Project Specific Variations:

- Risk identification and quantification
- Repayment Time
- Funding Source

The content analysis of the VfM processes indicates the overall process framework is similar between agencies but differences exist in specific areas such as who governs the process, the project demand risk allocation, and quantifying the financial uncertainty of time value of money. The research question looked to answer how does the evaluation process of determining if a public private partnership brings the best value for public money differ between two different agencies in the US and NZ. The results of the investigation show by use of a VfM analysis, public entities in the US and NZ are able to determine if the P3 delivery method will bring their project the most value. There are some differences within the VfM analysis process between the two entities but the overall methodology of determining best value to the public is similar between VAP3 and NZTA.

ACKNOWLEDGMENTS

The authors acknowledge the cooperation from staff from the Virginia Office of P3's and the New Zealand Transport Agency.

CHAPTER 5
QUANTIFYING MEGA-PROJECT VALUE FOR MONEY: DESIGN-BUILD VERSUS PUBLIC PRIVATE PARTNERSHIP DELIVERY METHODS

Barutha, P. and Gransberg, D.D. "Quantifying Mega-Project Value for Money: Design-Build versus Public Private Partnership Delivery Methods," *Journal of Management in Engineering,* ASCE (submitted April 2016)

While the previous chapter was aimed to get a better understanding about the overall framework for value for money assessment of P3 projects, this chapter is intended to determine what the value for money is in a P3 project. Chapter 5 presents a complete case study analysis of two different project delivery methods, P3 and DB, and how each achieved VfM and what the difference in VfM was from one to the other. The case study analyzes information gathered from two infrastructure projects in the US, one in Missouri and one in Pennsylvania, with similar size and scope. This case study analysis provides a better insight to agencies on the additional value brought with involving the private sector in project finance and long-term maintenance.

Abstract

The traditional low bid procurement method for construction of an infrastructure project is one method of demonstrating value for money (VfM) to the public as it relies on competition to ensure the best price. Public private partnership (P3) project delivery challenges the idea that value is totally defined by minimizing project cost. P3 projects permit public agencies to extend the value calculus beyond construction completion to the development, design, operations and maintenance phases of a project as well as to gain access to private finance to cover the gaps in public funding shortfalls. This study compares VfM between P3 delivery in Pennsylvania to design build (DB) delivery in Missouri to determine the change in VfM if the project is delivered

under P3. The study identifies similar value added efficiencies gained within both P3 and DB delivery in bundling multiple bridge replacements in one single contract for design and construction. The study has also shown the benefit of having infrastructure built in present time with the involvement of private finance and the benefit of the private concessionaire's involvement in life cycle decisions with an increased project design life of the infrastructure.

Introduction

According to Burger and Hawkesworth (2011), "value for money … should be the driving force behind traditional infrastructure procurement… [and] undertaken only if it creates value for money." They go on to postulate that the choice of project delivery method "should be simple: governments should prefer the method that creates the most value for money." With the increased use of alternative project delivery methods, many US public agencies now have the flexibility to utilize the method that appears to provide the best value for money (VfM) for their specific project.

This research uses data from a design-build (DB) mega-project in Missouri and a similar public private partnership (P3) mega-project in Pennsylvania as the basis to measure and compare the VfM of each project. Both projects were configured to deliver over 500 structurally deficient rural bridges in a single contract. The Missouri Department of Transportation (MoDOT) chose to use design-build (DB) project delivery for the design and construction of 554 farm to market road bridges (Heckman 2012). The Pennsylvania Department of Transportation (PennDOT) used P3 project delivery for a package of 558 similar farm to market road bridges using the design build finance maintain (DBFM) variation of P3. In projects of this nature, VfM is often demonstrated through reduced project delivery periods and increased cost and time

certainty. This leads one to posit whether or not more VfM can be accrued by further involving the private sector in a mega-project's financing scheme and post-construction maintenance via P3 delivery. Therefore, the research proposes to answer the following question:

Does VfM increase if a mega-project is delivered using Design Build Finance Maintain (DBFM) of P3 versus DB?

Previous studies have compared the performance of design-bid-build (DBB) and DB projects using metrics like time and cost growth. Hale et al. (2009) found that DB projects "were proven superior in performance in almost every measure." Other studies have found, "timesaving was a definitive advantage of design/build project delivery, but, the positive effects of cost and productivity changes were not convincing." (Ibbs et al. 2003) A 2008 study found that "design-build projects performed better than design-bid-build projects in terms of cost and schedule and were comparable in quality outcomes." (Gransberg 2008) These previous studies have shown there are opportunities for agencies to accrue value from involving the construction contractor into the design process of design and construction of a public project in terms of both cost and time performance (Gransberg 2013). However, design and construction are just two phases of a project's life cycle. Before the design phase, a project development and finance plan are needed, and following construction, agencies must operate and maintain the facility throughout its service life.

As the deterioration of the nation's highway network reached critical stages, public agencies have increasingly turned to the private sector to accelerate the design and construction process

through DB contracts and now some public agencies are also asking the private sector to design, build, finance, operate, and maintain highway assets as a means to bring additional value to their projects. (Yescombe 2007) P3s incorporate these additional phases of the project life cycle. One variation is referred to as Design Build Finance Operate and Maintain (DBFOM). While public agencies see the value of involving the private sector into the post-construction phases of a project life cycle, many agencies are challenged with how to quantify the value gained of private sector involvement in the post-construction phases. As a result, the objective of this study is to compare a DB project of similar scope, complexity and magnitude as a P3 project to provide better understanding of perceived and actual VfM. In essence, since the comparison is DB versus DBFM, the hypothesis being tested is as follows:

Adding private financing and maintenance to a DB project yields greater VfM than merely delivering the project using DB.

Background

"The increasing use of the design-build delivery method has resulted in it now being one of the most popular nontraditional methods for delivering road, bridge, mass transit, and rail projects in the United States" (Gatti 2014). As previously indicated, many studies have shown multiple benefits of delivering a project using the DB method. Tangible performance metrics such as budget and schedule performance have been used to quantify the costs and benefits of DB along with other intangible metrics like conforming to expectations and owner satisfaction (Molenaar 1999). Figure 5.1 depicts some of the typical metrics used to measure VfM when considering DB project delivery. (FHWA 2006)

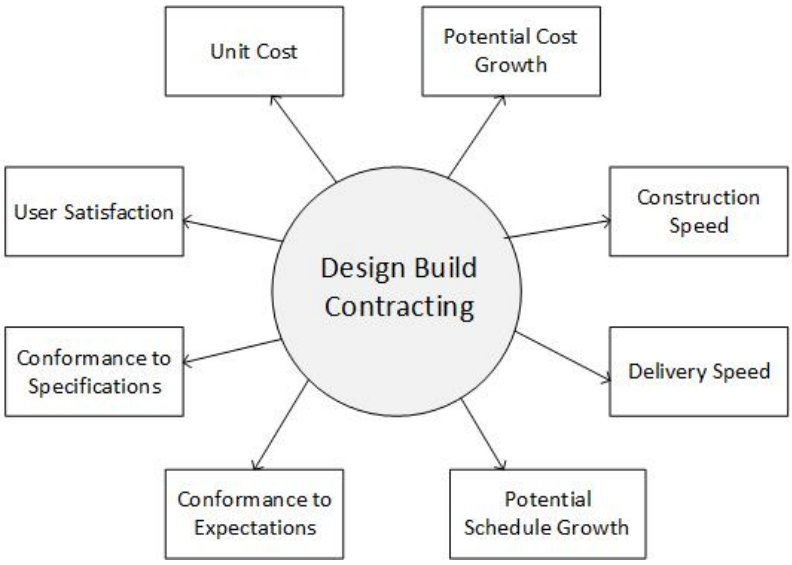

Figure 5.1: DB Project Delivery Evaluation Criteria (adapted from FHWA 2006)

Reduced cost and schedule growth are often cited as typical benefits of DB project delivery. Three studies conducted (Hale et. al 2009) comparing DBB with DB highway projects in the mid 2000's found that DB projects generally offer better cost and schedule certainty. For example, The Federal Highway Administration (2006) conducted a study showing DB Projects had schedule growth 9% lower than that for DBB. Shrestha's (2007) study of 11 DBB and 4 DBB highway projects found that DB projects had 9.6% less cost growth than DBB projects. This increased cost and time certainty has shown to be a major benefit of the DB project delivery. The FHWA (2006) study also revealed that agency contract administration and inspection costs were reduced in DB projects. From the same study found that DB projects had fewer change orders due to design inadequacies than DBB projects. This further supports the idea there are benefits of engaging the contractor earlier in the design phase.

P3 mega-projects have also experienced the benefit of enhanced cost and time certainty. Flyvberg, et al. (2002) studied 258 large transportation infrastructure projects in 20 countries, and the majority were delivered using "conventional approaches to public procurement." The study found in 90 percent of the projects the costs were "substantially". MacDonald (2002) conducted a study for UK Treasury of 50 large public procurement projects in the UK over the last 20 years; 11 projects were P3s. It found that the P3 projects all were completed ahead of schedule as compared to a 17 percent schedule growth for the others. P3 capital expenditures were observed to be 1 percent over budget on average. Whereas the traditionally procured projects experienced an average cost overrun of 47 percent Grimsey (2005) stated that:

> "Further evidence for the UK comes from HM Treasury (2003) in its own review of 61 P3 projects, where it was found that 89 percent of the P3 projects were delivered on time or early and that all P3 projects were within budget. About 75 percent of major infrastructure projects in the UK were late and over budget before P3's came into play. Under P3 arrangements, 75 percent of projects are on time and on budget" (Grimsey 2005).

As a result of the above discussion it is apparent that both DB and P3 provide the potential for a public agency to enhance a project's VfM over traditional project delivery methods. Therefore, the question becomes which one adds the greater value.

Economies of Scale

Conventional wisdom holds that as the quantities produced of a given product increase that the unit cost of that product drops (McCarthy and Anagnostou 2004). The same phenomenon has also been observed in highway construction (Yeo and Tiong 2000; Williams 2003). By packaging 554 bridges into a single contract for, Missouri DOT sought to capture the

efficiencies due to economies of scale and therefore experience the cost and time savings found in these efficiencies. Economies of scale arise because of the inverse relationship between the quantity produced and per-unit fixed costs, i.e. the greater the quantity of a good produced, the lower the per-unit fixed cost because these costs are shared over a larger number of goods. Silbertson (1972) identifies six possible sources of achieving economies of scale: 1) initial fixed costs, 2) working capital, 3) specialization of labor, 4) vertical linking economies, 5) increased size, and 6) specialization of plant and/or equipment. Most of Silbertson's sources for achieving economies are in the DB and P3 case study projects collected for this paper. According to Akintoye (2005), "the achievement of economies of scale by developing an integrated solution is seen as an important and attractive opportunity to broaden the context of P3 to include projects that might otherwise not be considered as suitable for this type of procurement."

Most traditional bridge construction projects are limited to a single bridge and as such any economies of scale are limited to components of the bridge like precast concrete structural members. Hallmark et al. (2012) held that "the total cost of a bridge is not limited to the amount spent on concrete, steel, and labor… Construction activities disrupt the typical flow of traffic around the project and result in additional cost to the public in the form of longer wait times, additional mileage traveled to get around the work zone, or business lost attributes to customers avoiding the construction." This phenomenon is typically referred to as the user cost of construction (Herbsman 2005). This notion advocates that "Finding a way to shorten the time spent on the jobsite is beneficial to the contractor, the owner, and the traveling public." The bridge construction industry has long used pre-fabrication of bridge components to reduce the time a construction project will impact both the traveling public and the surrounding community.

Logically, as the amount of pre-fabrication increases, the unit costs decrease due to economy of scale. Additionally, since most of the work is performed off-site, the time that traffic is disrupted also decreases reducing user costs, and the overall project cost (Owens et al. 2011). This idea presented in Hallmark et al.'s study compliments the idea of achieving economies of scale. Pre-fabrication of bridge elements techniques were utilized on both case study projects and was examined during the case study analysis to determine the level of value this process brought to the two projects.

Hallmark et al.'s study also refers to the impact of the public, the road user. Herbsman (1995) conducted a study, which evaluated the impact to the road user from the delays and inconvenience caused by road construction and rehabilitation projects in the US. The study also evaluated the use of alternative contracting methods, including DB and P3, to reduce the overall impact to the road users. The study concluded that all alternative methods were successful in reducing construction times. Time reductions of 20-50% were observed versus similar projects delivered using conventional methods. Based on the result of this study, the researchers decided to measure road user impact as part of the case study project comparison.

"Maximizing value and minimizing waste at the project level is difficult when *the contractual structure inhibits coordination, stifles cooperation and innovation*, and rewards individual contractors for both reserving good ideas and optimizing their performance at the expense of others" (Matthews 2005 italics added). Findings from the Matthews study illustrate the benefits of integrated project delivery to include the following:

- Shared manpower,

- Problem resolution,
- Handling major changes to the work,
- Work across traditional boundaries,
- Avoid redundant effort and expense,
- Enhancements to job site safety, and
- Spending more to save more. (Matthews 2005)

This study also identifies four major systemic problems with the traditional contractual approach:

1. Good ideas are held back,
2. Contracting limits cooperation and innovation,
3. Inability to coordinate,
4. The pressure for local optimization. (Matthews 2005)

Molenaar (1999) found that "project cost and schedule performance was excellent under the design build method. 59% of the projects were with 2% or better of the budget established when the design builder was hired. 77% of the projects were within 2% or better of the schedule established when the design builder was hired." Molenaar et. al (2014) also state, DB's "main benefit is that it allows overlapping of the design and construction phases often reducing project completion time." Therefore based on the studies by Matthews and Molenaar et al, the decision was made to measure the benefits of integrated project delivery for the two case studies regarding difference between the level of integration achieved in DB versus P3 using DBFM project delivery.

Case Study Research Methodology

A case study is an empirical study and is the preferred strategy when "how" and "why" questions are being posed, when the investigator has little control over the events, and when the focus is within some real-life context (Yin 1994). Briefly, the case study allows the investigation to retain the holistic and meaningful characteristics of real-life events. Another benefit of using a case study is the ability to cover contextual conditions when the researcher believes that they might be highly pertinent to the analysis. In this sense, the case study is not either a data collection protocol or merely an experimental design feature, but a comprehensive research strategy. "Case studies can be based on any mix of quantitative and qualitative evidence" (Yin 1994). Case studies involving participant interviews allow the researcher to probe the rationale behind events that produced the project performance outcomes (Harris and Brown 2010), which in turn permits a context to be defined in a manner unlike more common analytical/statistical research instruments.

The primary input to the case study project analysis was gathered through face-to-face structured interviews with agency personnel, contractors, and consultants that participated in the delivery of the two projects. The structured interview questionnaire was developed on lines similar to the methodology prescribed by the US Department of Education (DOE) (ERIC/AE 1997). The DOE methodology is prescribed for use when the researcher needs to "spend considerable time probing participant responses, encouraging them to provide detail and clarification" (Harris and Brown 2010). The structured the interview is best used when "information must be obtained from program participants or members of a comparison group… or when essentially the same information must be obtained from numerous people for a multiple

case-study evaluation" (GAO 1991). Since both of these conditions apply to the problem at hand, the instrument is the appropriate tool for this research.

The process requires a questionnaire to be created and made available to case study project personnel being interviewed in advance of the interview. This permits them to prepare for the interview as well as to assemble any necessary information or documentation and have it available at the time of the interview. The questionnaire was designed using Oppenheim's (1992) approach. Both open and closed ended questions were included. The closed ended questions were used to ensure that specific perceptional information was collected on both projects; whereas the open-ended questions were intended to stimulate discussion of the interviewee's rationale for each answer as well as to collect factual information that was not included specifically in the questionnaire itself.

Once the face-to-face interview commences, responses are collected in the same order using the same questions for each interviewee. After each question and answer, the interviewer ensures that the interviewee understands the question and that the answer is fully understood by the data collector. Interviewees are allowed to digress as desired, allowing the researchers to collect potentially valuable information that was not originally contemplated.

The case studies analyzed using a protocol for cross-case comparison proposed by Yin (2004). The use of the structured interviews in conjunction with the information found in the literature allows the researcher to not only maintain a high level of technical rigor in the research but to also adhere to Yin's three principles of case study analysis:

1. Use of multiple sources,
2. Creation of a database, and
3. Maintaining a chain of evidence (Yin, 2004).

The interview analysis output is then used to derive both the agency's and the contractor's perspectives on VfM in each case study project.

The case study data collection and analysis process is shown in Figure 5.2. To answer the research question posed in a previous section, a set of three sub-questions were defined:

1. Is additional value added by private sector involvement in DBFM delivery as compared to DB delivery?
2. Is additional value added with including the private sector with the finance of the project?
3. Is additional value added by involving the private sector with the long-term maintenance of the project?

A total of four project participants were interviewed. The following is a list of their roles on each project:

- S&S DB Project: MoDot Project Director, KTU Constructors Project Director
- Rapid Bridge Replacement Project: PennDot Director of the P3 Office, Plenary Walsh Keystone Partners Chief Operating Officer

The collection of each case study commenced by contacting the agency telephonically to identify the both the agency and contractor's project participants. The initial contact also included a request for project documentation that was used to develop the questionnaires. A date and time for the interviews was established and the research team traveled to the designated site

to conduct the interviews. Because of the scope of the two projects including over 500 bridges, no attempt was made to visit the project sites. However, a map of the locations of the projects was made available during the interviews to give both the researchers and the interviewees a common document upon which to make reference. Once the interviews were complete, the researchers reduced the data and sent it to each agency to verify that it was correct. The final step was to analyze the results and use the output to test the hypothesis.

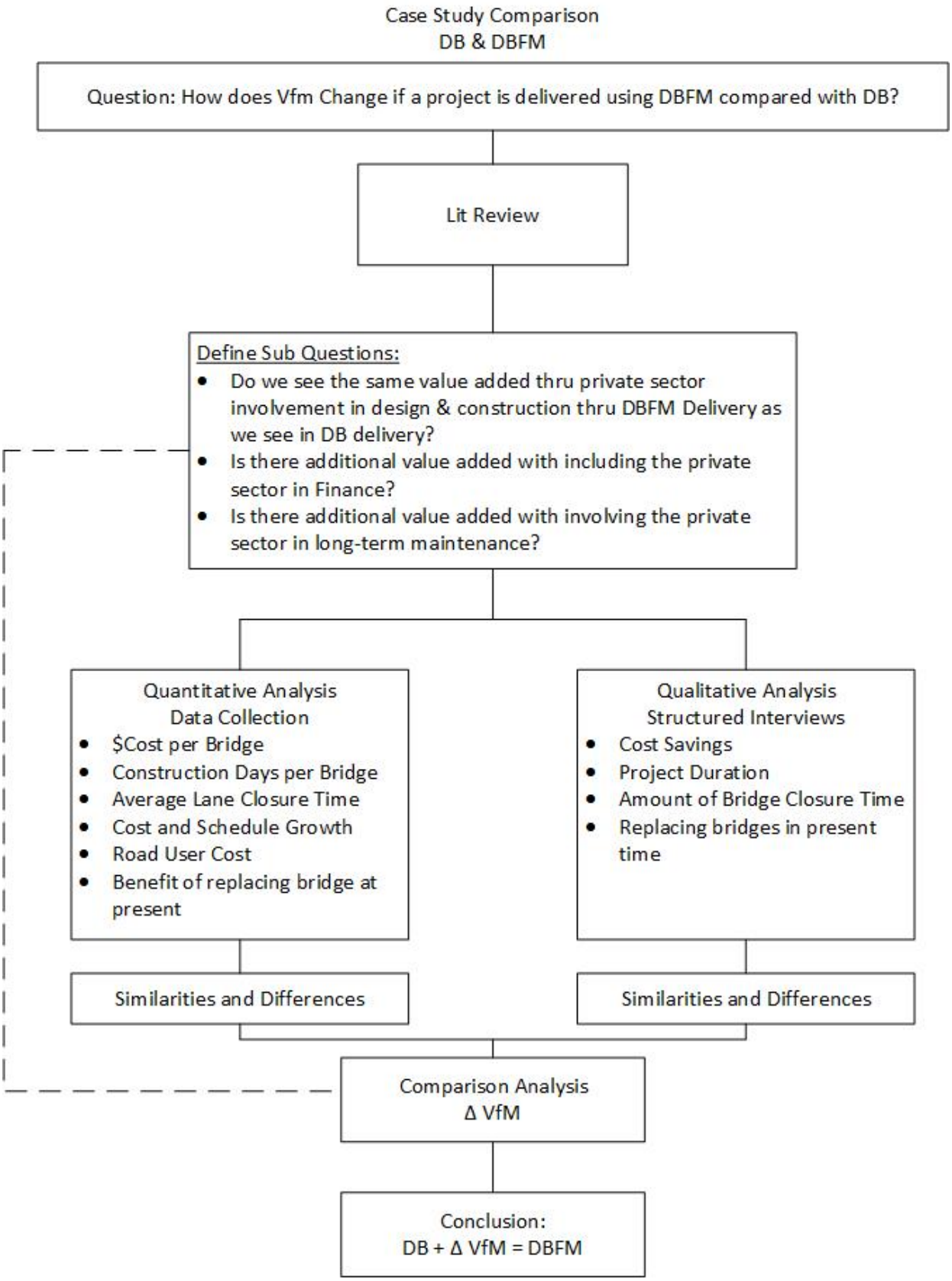

Figure 5.2: Case Study Methodology.

Case Study Analysis

The two case study projects selected were selected based on being similar in size, scope, and delivery time. The details are shown in Table 5.1. The DB project selected for case study is the Missouri DOT S&S Project comprising 554 rural bridges located statewide. The DBFM project case study is the Pennsylvania DOT RBR Project consisting of 558 rural bridges located statewide. The S&S Project was awarded in 2009 and completed in 2011. The RBR Project began design and construction in 2015 and has an anticipated completion in 2017.

Table 5.1: Case Study Project Description.

Case Study Description		
Description	**Design Build**	**Design Build Finance and Maintain**
Agency	Missouri DOT	Pennsylvania DOT
Project Title	Safe and Sound	Rapid Bridge Replacement
Project Type	Structurally Deficient Bridge Replacement	Structurally Deficient Bridge Replacement
Project Location	Statewide - Rural	Statewide - Rural
Number of Bridges	554	558
Number of Counties	111	66
Private Sector Contract Scope	Design and Construction	Finance, Design, Construction, and 25 year Maintenance
Notice to Proceed Date	November, 2009	June, 2015
Design and Construction Duration	36 Months	31 Months
Project Cost	$487,000,000	$899,000,000
Private Finance Contribution	N/A	$793,000,000
O & M and Finance Costs	N/A	$220,000,000
% of Structurally Deficient Bridges at Start of Construction	Approximately 50% had some type of restriction	Approximately 20% had some type of restriction

Quantitative Results

Table 5.2 contains the results of the quantitative analysis. As can be seen a number of metrics were developed to permit a cross-case comparison on a quantitative level. Since the major operational difference of the two projects was the addition of contractor financing and a post-construction maintenance period to the P3 project, the metrics used for comparison were designed to separate the pre-construction and post-construction aspects to clearly identify the impact of financing and maintenance by the agency versus by the private sector.

Table 5.2: Case Study Project Quantitative Outcomes.

Case Study Quantitative Results		
Description	**Design Build**	**Design Build Finance and Maintain**
Agency	Missouri DOT	Pennsylvania DOT
Project Title	Safe and Sound	Rapid Bridge Replacement
Project Cost	$487,000,000	$899,000,000
Private Finance Contribution	N/A	$793,000,000
O & M and Finance Costs	N/A	$220,000,000
% of Structurally Deficient Bridges at Start of Construction	Approximately 50% had some type of restriction	Approximately 20% had some type of restriction
$ per Bridge (DB/P3)	$879,062	$1,611,111
$ per Bridge (Traditional)	$1,024,433	$1,722,781
Average Schedule Days per Bridge (DB/P3)	43 Days	55 Days
Average Schedule Days per Bridge (Traditional)	90-120 Days	Data not available
Average Road User Cost per Bridge per Day	$36,859	$22,907
Life Expectancy of Bridges	50 years	100 years

Cost per Bridge

A comparison was made to determine the cost of building a bridge using the traditional method compared to bundling the design and construction of the bridges using DB or P3

methods. Using average cost per bridge was determined to be the best unit of comparison to compare the costs of the different projects. Both case study projects were comprised of over 500 rural bridges crossing streams located throughout their respective states. Samples of conventional single bridge projects were gathered in each state to permit the quantification of the impact of bundling multiple projects for each state. The Missouri sample consisted of 31 DBB projects of comparable scope and size to those deliver in the S&S project taken from bid results from January 2014 to December 2015. The Pennsylvania sample consisted of 28 projects of comparable scope and size to the RBR project taken from bid results from July of 2013 to June 2014.

Table 5.3: Traditional versus Bundled Contract Details

	Missouri		**Pennsylvania**	
	S & S	**Traditional**	**RBR**	**Traditional**
Number of Bridges	554	31	558	28
Construction Period	November 2009 - November 2011	January 2014 - December 2015	June 2015 - December 2017	July 2013-June 2014
Includes Design Cost	Yes	No	Yes	No
Cost per Bridge	$879,062	$1,024,433	$1,611,111	$1,722,781
Approximate Design Costs	Included Above	10-15% of Bid Amount	Included Above	10-15% of Bid Amount
Difference in Cost per Bridge between DB/P3 to Traditional	($145,371)		($111,670)	
Design Life Expectancy (years)	50	-	100	-
Cost per Bridge per Year of Design Life	*$17,581.24*		*$16,111.11*	

The cost savings Missouri's S&S Project was equal to approximately $145,371 per bridge. This does not include any design savings the state may have experienced due to economies of scale achieved in the S&S project process. The cost savings Pennsylvania's RBR Project was approximately equal to $111,670 per bridge, which also includes design costs so there is

potential for additional savings if design costs of traditional procurement are factored in as well. A state to state cost comparison between Missouri's S&S Project and Pennsylvania's RBR Project was performed using a simple calculation of dividing the total cost per bridge by the Design Life Expectancy in years. The S&S Project had a total Design Life Expectancy of 50 years while the RBR project had a total Design Life Expectancy of 100 years.

- Safe and Sound: $17,581 per bridge per year of design life
- Rapid Bridge Replacement Project: $16,111 per bridge per year of design life

Time per Bridge

Missouri and Pennsylvania both experienced time savings in their projects. Missouri was originally scheduled to complete the 554 bridges in 36 total months, and Pennsylvania is scheduled to complete the 558 bridges in 31 total months. The average number of days to complete a bridge under S&S was 43 days, as compared to a typical bridge construction completion schedule of 90-120 days per bridge in Missouri. The RBR Project is scheduled to have an average of 55 days to complete each bridge. There was no information available to include the typical construction schedule days to complete a bridge in Pennsylvania. The S&S Project has demonstrated some clear time savings experienced from typical bridge construction in Missouri with a total time savings of greater than 45 days per bridge.

Road User Costs

"Road User Costs are defined as the estimated incremental daily costs to the traveling public resulting from construction work being performed. Those costs are primarily time lost because of conditions such as detours/rerouting that add to travel time, reduced roadway capacity that slows travel speed and increases travel time, or a delay in the opening of a new or improved facility that prevents users from gaining travel time benefits" (Daniels et. al 2005). Average road user cost was used to determine the monetary benefits to the public road user affected by each project. The average road user cost consists of both vehicle operating expense and the cost of time to the driver impacted by the detour of the bridge closure.

Vehicle Operating Expense:

Cost per mile (Automobile): $0.54 (MDOT 2016)

Cost per mile (Truck): $1.87 (MDOT 2003)

Cost of Time to Driver:

Cost per hour (Automobile): $18.00 (MDOT, date)

Cost per hour (Truck): $31.76 (MDOT, date)

Table 5.4 shows the traffic data collected for both projects, and Table 5.5 illustrates the results of the user cost analysis.

Table 5.4: Project Traffic Data

	Safe and Sound	Rapid Bridge Replacement
Average ADT per Bridge	1800	2700
Percent of Trucks per Bridge	10%	9%
Average Detour per Bridge	20 miles	8 miles

Table 5.5: Average Road User Detour Cost Per Bridge Per Project.

	Safe and Sound Project		Rapid Bridge Replacement	
Vehicle Operating Expense	Automobiles	Trucks	Automobiles	Trucks
AADT	1680	180	2457	243
Cost per Mile	$0.54	$1.87	$0.54	$1.87
Average Detour	20 miles	20 miles	8 miles	8 miles
Subtotal per Bridge	$18,144	$6,732	$10,614	$3,635
Cost of Time of the Driver				
AADT	1680	180	2457	243
Cost per Hour	$18.00	$31.76	$18.00	$31.76
Avg. Detour Time	0.333 Hours	0.333 Hours	0.167 Hours	0.167 Hours
Subtotal per Bridge	$10,079	$1,904	$7,371	$1,286
Average Detour Cost	$36,859		$22,907	

One can see the benefit to the public of Missouri with completion of the S&S bridges in half the time it took to complete a typical bridge replacement. Quantifying the road user benefits of completing the construction of the replacement bridges in half the time can be conservatively be approximated as follows:

(Avg. Comp. Days per Bridge$_{Traditional}$ – Avg. Comp. Days per Bridge$_{S\&S}$) X Avg. Detour Cost per Bridge per day X Total Bridges = Total Benefit to Public Road Users of Missouri

Total Benefit = (90 days – 43 days) x $36,859 x 554 bridges = $959,734,642

The time savings experienced during construction of the S&S Project gave a monetary benefit to the public road users travelling through the state of Missouri of approximately $900 million.

Qualitative Results

Structured interviews were conducted with all parties, public and private, on both the S&S and RBR Projects. As previously stated, this study was seeking to answer the "how" and "why" and was seeking to compare the similarities and differences between the two projects and the quantitative results. Interviews were conducted in March of 2016 with a representative of Missouri DOT supervising the S&S Project and the project manager of the private DB firm designing and constructing the project. A representative of PennDot supervising the RBR Project was interviewed in March of 2016 and, in a separate interview, the supervisor for the private concession group designing, building, financing, and maintaining the RBR project. The following questions were posed to all parties:

1. What do you think Value for Money is?
2. What factors do you believe resulted in project cost savings?
3. What factors do you believe contributed to a shortened project schedule?
4. What factors do you believe contributed to reduce the amount of bridge closure time?
5. What are the benefits of replacing the bridges in present time?

Questions reserved for the RBR Project Dot and private concession group (DBFM):

6. What are the benefits of involving the private sector with the finance of the project?
7. What are some of the benefits of having a long-term maintenance agreement with the Concession group that designed and built the project?

Each interviewee was asked to identify what factors led to achieving the desired question and to rank the number one factor to achieving each question. Table 5.6 is a list of the top responses combined for both projects, including both public and private perspectives.

Table 5.6: Qualitative Analysis Outcomes

	Question Description	Top Response(s) (4 Total Responses)
1.	What do you think Value for Money is?	Quantitative analysis
2.	What factors do you believe resulted in project cost savings?	Standardized design
		Economies of scale
		Use of pre-fabricated materials
3.	What factors do you believe contributed to a shortened project duration?	Use of pre-fabricated materials
4.	What factors do you believe contributed to reduce the amount of bridge closure time?	Designing in reduced closure time
		Standardized design
		Use of pre-fabricated materials
5.	What are the benefits of replacing the bridges in present time?	Do not need to place load restrictions on bridges impacting local economy
	Rapid Bridge Replacement Project Only (DBFM)	**Top Response(s) (2 Responses)**
6.	What are the benefits of involving the private sector with the finance of the project?	Ability to replace the bridges in the present time
		Life Cycle Decisions, i.e. higher quality over the
7.	What are the benefits of having a long-term maintenance agreement with the Concession Group that designed and built the project?	Life Cycle Innovation

See Appendix A for complete list of responses.

The results from the structured interview illustrate how the bundling of the bridges into one single Design and Construction Agreement (DB – S&S, DBFM – RBR) was able to not only reduce the overall cost of the bridges, but also reduce the overall construction time and the amount of bridge closure time. The benefits of the bundling into one single agreement include: 1) Standardized Design, 2) The use of Pre-Fabricated Materials, 3) Designing in reduced closure times, and 4) Economies of Scale.

Value for Money by Private Finance

"77% of all bridges nationwide and 63.5% of all structurally deficient bridges are located in rural areas illustrating the potential that inadequate and maintenance funding to keep those rural bridges operating at their current structural load capacities could have an enormous economic impact on a state's economy" (Davis, et. al 2013). Miller et al. (2015) posited that the deteriorated condition of the nation's transportation system costs the U.S. economy $129 billion each year. The problem is more pronounced in states where agriculture is a significant portion of its economy. "The effects of ignoring low-volume bridges has been publicized in studies, which found that agricultural states, with vast rural areas, have a large number of deficient bridges." The state of Pennsylvania has some of the most structurally deficient bridges in the country (Miller and Gransberg 2015).

The structured interview results provided a valuable insight to identifying the value of including private finance with public infrastructure project delivery. One of the top benefits identified by the RBR project team was using private finance to allow the ability to replace bridges in the present time. Both project teams in Missouri and Pennsylvania identified the top benefit of replacing the bridges in present time was not needing to place load restrictions on bridges impacting the local economy. This study examined the benefit to the public of using private finance to develop infrastructure, in this case, using private finance to fund the replacement of bridges in the state of Pennsylvania. At the time when the RBR Project was starting, PennDot had identified 20% of the total number of bridges to be replaced under the RBR project were found to be structurally deficient and some sort of load restrictions were placed on the bridges.

Load restrictions on bridges impact the total weight of the load crossing the bridge, meaning there is a reduction in the total load allowed to cross the bridge or in some situations the bridge is closed to vehicles of any weights. This reduction in allowable load negatively impacts the road users by having to use an alternate route, or detour, around the structurally deficient bridge often times incurring more travel miles and time around the detour. Miller et al. 2015 have utilized a method of determining an economic impact of structurally deficient bridges. "To conduct this analysis, it was first necessary to identify stakeholders for each bridge. The study only considered the bridge's users as stakeholders since these are the most impacted. Users were classified in two categories based on different economic impact: light to medium vehicles and heavy vehicles." A similar method of calculating economic impact due to the structurally deficient bridges was utilized for this study.

Using a hypothetical scenario, where structurally deficient bridges were not able to be replaced for a year due to lack of funding and without the ability to use private finance, the economic impact to the users of the rural road network in Pennsylvania can be determined in a similar manner to Table 5.5. Using the previously calculated road user cost (Table 5.5) and assuming that 20% of the RBR bridges are structurally deficient bridges, the impact is calculated and shown in Table 5.7. The study shows the economic impact of a conservative scenario where there are only reduced load restrictions imposed on the bridges impacting only heavy vehicles, and worst case scenario where all structurally deficient bridges are closed to the travelling public, both light to medium vehicles and heavy vehicles.

Table 5.7: Cost of a Hypothetical One Year Delay in RBR Project

	Scenario 1	Scenario 2	
Vehicle Operating Expense	Heavy Vehicles	Heavy Vehicles	Light to Medium Vehicles
AADT	243	243	2457
Cost per Mile	$1.87	$1.87	$0.54
Average Detour	8 miles	8 miles	8 miles
Subtotal per Bridge	$3,635	$3,635	$10,614
Cost of Time of the Driver			
AADT	243	243	2457
Cost per Hour	$31.76	$31.76	$18.00
Avg. Detour Time	0.167 Hours	0.167 Hours	0.167 Hours
Subtotal per Bridge	$1,286	$1,286	$7,371
Average Detour Cost per Bridge	$4,922	$4,922	$17,985
20% Structurally Deficient	111 Bridges	111 Bridges	111 Bridges
Delay Time to Replace Bridge	365 Days	365 Days	365 Days
User Cost to Delay Bridges	$199,397,003	$199,397,003	$728,671,999
Total Cost to User per year	$199,397,003	$928,069,002	

Using the conservative scenario (Scenario 1), the benefit of having the bridges replaced in present time (one year earlier) to the users of the rural road network in Pennsylvania is approximately equal to $200 million per year. Based on this analysis the approximate VfM of private finance on the RBR project will range from $200 million to as much as $1.0 billion annually.

Value for Money of Private Long-term Maintenance Partnership

"Whole-life costing is perhaps the most important element of the VfM case for PPPs." (Yescombe 2007) The project team for the RBR project identified life cycle innovation as the greatest benefit of contracting the designer and builder to maintain the project for 25 years. An example of how this benefit was incorporated in the RBR project was the use of a polymer overlay as the road surface for the bridges being replaced. This technology increased the initial construction costs, but reduced the amount of resurfacing treatments required at each bridge thus

reducing the overall costs needed to maintain the bridges for their life cycle. This improved the overall life cycle quality of the project while reducing the overall life cycle costs. While the FHWA requires life cycle cost analysis to be performed on all federally funded bridge projects (Hawke 2003), life cycle considerations are often overcome by the stark financial reality of insufficient availability of the necessary funding (Gransberg et al. 2013). Additionally, the requirement for the contractor to maintain the facility for a concession period after construction creates a tangible incentive to making design decisions in a manner that minimizes life cycle cost (Garvin 2011).

Since the RBR project is not complete at this writing, there is no data available to perform a quantitative analysis on the total maintenance costs or benefits of using private industry for long-term maintenance of the project, but by extrapolating the qualitative information from the parallels found with the structured interviews, there is sufficient information to reasonably infer there is verifiable VfM associated with involving the private sector in the long-term maintenance of the project.

Conclusion and Discussion

The study sought to determine how the VfM changes if a mega-project is delivered using P3. To answer this question, a comparative analysis of two case studies of roughly the same size, type, and complexity were compared both quantitatively and qualitatively. The study investigated three phases of a public infrastructure project, the finance and development phase, the design and construction phase, and the long-term maintenance phase. The following conclusions are drawn from the cross-case comparative analysis:

- Similar value was found in the design and construction phase for DB and P3-DBFM both quantitatively and qualitatively. Quantitatively, cost savings and time savings were observed in both projects. Qualitatively, by bundling the replacement of the bridges under a single contract, benefits were identified via through standardized design, pre-fabrication, reduced closure times, and economies of scale. Specifically, the following results were obtained:
  - Calculated cost savings ranged from approximately $100,000 to $150,000 per bridge
  - Calculated time savings were roughly 50% time savings per bridge on S&S project.
- By using private finance the RBR Project was able to replace bridges well in advance of when they could using 100% public finance. The qualitative assessment shows the benefits of using private finance in development of the project to be 1) the ability to replace the bridges in present time and 2) an increased life cycle expectancy due to having available funds. The value to public of having bridges built in present time reduces the travel delay time due to detours around closed or load restricted bridges. That benefit was estimated to be between $200 million and $1.0 billion per year of road user cost savings.
- Including private sector long-term maintenance on the project increases VfM. The evidence is shown in the RBR contractor's decision to design and build bridges with a 100 year design life literally twice that observed in the S&S project. While not included in the study, there is also an unquantified value associated with the transfer of risk to the RBR contractor for long-term maintenance of the project.

To summarize, the study shows that increased VfM can be quantified to support the use of P3 project delivery accruing benefits by replacing needed infrastructure in the present time by use of private finance as well as transferring infrastructure life cycle maintenance risk. The study also demonstrated the increased VfM associated with bundling multiple small projects into a single mega-project with both case studies demonstrating substantial cost and time savings over traditional single bridge contracts.

This study illustrates how a public infrastructure mega-project delivered as a P3 permits the demonstration of VfM to the public by the public agency and can be a valuable contracting tool for public agencies to use in developing their projects. One of the posted goals for MAP 21 from the FHWA is "Reduced Project Delivery Delays - To reduce project costs, promote jobs and the economy, and expedite the movement of people and goods by accelerating project completion through eliminating delays in the project development and delivery process, including reducing regulatory burdens and improving agencies' work practices". (FHWA 2015) This research has demonstrated how both MoDOT and PennDOT have utilized alternative project delivery to achieve this national goal to bring value for money to the public which they serve.

Limitations

It must be noted that having two nearly identical, save location and delivery method, mega-projects is a highly fortuitous situation for the research team. Thus, while the conclusions listed above are well-supported by the data, one must be careful in attempting to generalize the findings to the universe of public infrastructure projects. It is impossible to "calibrate" or "extrapolate" the findings beyond the two case study projects with any degree of confidence.

Nevertheless, the findings must be judged as promising and may easily be used to demonstrate the potential VfM found in both bundled contracts and seeking private finance and maintenance via P3 project delivery.

CHAPTER 6
PROJECT RISK IMPACT ON PUBLIC PRIVATE PARTNERSHIP MEGAPROJECT VALUE FOR MONEY

Barutha, P. and Gransberg, D.D. "Project Risk Impact on Public Private Partnership Megaproject Value for Money," *Journal of Construction Engineering and Management*,ASCE (submitted April 2016)

This chapter describes the impact of project risk on P3 projects in the US. This chapter presents a study on risks present in P3 projects and what the impact each risk has on VfM. Transfer of risk from the public to the private sector is a major benefit of P3 project delivery. This article provides insight into what level of importance each risk has to each stakeholder in a P3 project, to allow agencies to find an optimal risk allocation for each project to provide the best value for money.

Abstract

Risks and resources are shared for the purpose of delivering a public service in a public private partnership (P3). Proper risk identification and allocation is at the heart of all P3 projects, with the theory of successful P3 delivery having the ability to transfer the risk to the entity best able to manage the risk brings the project the most value for money (VfM). Complex infrastructure megaprojects contain many risks throughout the life cycle of the project beginning in development through design and construction to operations and maintenance of the facility. In order for public agencies to determine the proper risk transfer and VfM, they must first have the ability to properly identify and quantify the value of risk within each project. The public and private sector may not perceive the amount of impact each specific risk has to the project, therefore the value of transfer of each specific risk may vary between the public and the private sector. This research provides some perceptional information on what level of impact each risk

presents to the public and private sector and can be used as a useful comparison of relative importance of each project risk in determining an optimal project risk allocation between parties.

Introduction

Public Private Partnerships (P3) provide public transportation agencies with an option to fund and develop infrastructure projects in the United States when public funding is not forthcoming. "Limited highway funds, unmet needs for new highway capacity, interest from private investors, and other factors have led to a substantial discussion of (P3) projects." (Brown 2009) At a time when the American Society of Civil Engineers (ASCE) *Report Card on America's Infrastructure* found that "32% of America's major roads are in poor or mediocre condition, costing U.S. motorists who are traveling on deficient pavement $67 billion a year, or $324 per motorist, in additional repairs and operating costs" (ASCE 2013), the infusion of private sector capital cannot be ignored. Especially since these private resources are readily available to help fund these projects (Melton and Dilley 2016). When examined from this perspective it seems a public-private-partnership (P3) is a logical solution to this problem.

P3 Theory

"Public Private Partnerships (P3) can be described as a … contractual arrangement between a public sector agency and private sector concern, whereby resources and risks are shared for the purpose of delivering a public service, or for developing public infrastructure." (Akintoye et al. 2003) "P3 arrangements are founded on the transfer of risk from the public to the private sector in circumstances where the private sector is best placed to manage the risk." (Grimsey and Lewis 2004) "Transferring some of the risk to a private party which can manage it at less cost can reduce the overall cost to the government." Before choosing P3 project delivery,

the agency must be able to demonstrate the Value for Money (VfM) to the public communities it serves. According to Yescombe (2007), "Value for Money is the combination of risk transfer, whole-life cost and service provided by the facility, as a basis for deciding what offers the best value to the Public Authority." The public VfM argument must be both defensible and logical, and often has its roots in the public sector's inability to provide the necessary financing at the point in time in which it is needed. This benefit must offset the potential cost of risk assumed by entering into a P3 arrangement as the "overriding aim … [in]P3 projects is to strike a sensible balance between risk transfer and value for money." (Akintoye et al. 2003)

P3 Risk

"Construction is a risky endeavor. Many things can go wrong in a construction project, especially if it is very complex." (Akintoye et al. 2003) The design and construction of a large infrastructure project is well documented as having a commensurately high amount of risk associated with it. P3 delivery adds additional elements of risk such as operations and maintenance risk and financial risk to the private sector. Often, public agencies are looking for private investors to finance their projects for multiple years. "Financial implications are at the heart of every business transaction and decision." (Weaver 2008) The private sector lives by the financial health of the organization.

All projects contain their own unique risk profile. P3 project risks can include, revenue risk, development risk such as permitting, environmental risk, utility risk, to name a few. "The private sector bears the design, construction, operations, and maintenance risks in all the nations visited. The handling of other risks varied, particularly the treatment of demand risk" (Garvin

2010). P3 projects inherently carry much risk for the private sector to absorb. Using modern finance theory this risk can be quantified and the appropriate amount of risk can be determined for a given level of expected return. "The tough part of decision making under uncertainty lies in deciding how much extra return should be required to accept different levels of risk" (Weaver 2008).

This research looks to evaluate how different infrastructure project risks affect the overall VfM to both the public and private sectors. Ultimately, as Akintoye et al. (2003) have indicated, the aim of project risk allocation is to find the balance point between VfM and risk transfer. Public agencies are used to shedding rather than sharing risk in traditional design-bid-build (DBB) projects. Research has shown that risk sharing results in increased cost and schedule certainty for both the public and private sectors (Jin and Doloi 2008). Classic risk allocation theory supports the concept that risk can be shared between the public and private sectors (Touran and Wiser 1992) and is thought to be the key to achieving VfM on P3 projects (NAO 1999, Grimsey and Lewis 2005). "If the private sector are asked to accept responsibility for a risk that is within their control, they will be able to charge a price for this part of the deal which is economically appropriate. However, if the [public agency] seeks to transfer a risk which the private sector cannot manage, then the private sector will seek to charge a premium for accepting such a risk, thereby reducing value for money" (NAO 1999).

Given the above discussion, one can infer that P3 project success is dependent on structuring the procurement in a manner that spreads the risk profile over some optimum distribution that represents a fair and equitable sharing of the risks between the public and

private entities involved in the project. Melton and Dilley (2016) maintain that "governments are seeking out ways to share risk… [So] why not find ways to share ownership as well." Therefore, P3 provides a vehicle for sharing both the risk and the ownership, which in theory should result in some desired return on the investment of the resources applied to the project. Hence this study seeks to answer the following research question:

How do individual P3 project risks impact perceived VfM in the public and private sector?

Objectives of the study

The objective of this paper is threefold. First, it will identify the primary areas of P3 risk to furnish a foundation upon which the analysis can be conducted. Next, it will collect via interviews both public agency and private sector perceptions of relative impact of each area of risk. Finally, the interview outcomes will be used as a comparative analysis of similarities and differences in perceptions of the individual risks with an aim of proposing a strategy for balancing the risk profile of a given P3 project.

Background

"Risk on a P3 (project) relates to uncertain outcomes which have a direct effect either on the provision of the services or the financial viability of the project." (Yescombe 2007) Many articles and studies conducted internationally on risks present in P3 projects and have identified possible risk allocation between the public and private sector (Ke et al. 2009). "No project is risk free. Risk is manageable, diminishable, transferable or acceptable but not ignorable." (Lam et. al) Finding VfM to the public on a project is finding the right balance of transfer of risk and value for money. "In order to achieve value for money objectives in the public project, the

public and private sector partners need to reach a mutually acceptable risk allocation scheme before the contract is awarded" (Bing et. al 2004). Grimsey and Lewis (2004) go further to state, "optimal risk allocation aims to minimize both the chances of project risks materializing and the consequences if they do." Optimal risk allocation has two elements: optimal risk management, and value for money. Grimsey and Lewis (2004) state: "The first of these is based on the view that the party best able to control a risk should be allocated that risk. The second element – VfM – is related to the first, in that the party best able to manage a risk should also be able to manage it at the least cost."

The prevailing theory for P3 project development concludes that the entity with the best ability to manage each specific risk will bring the project the most VfM. "Although many risks are in the control of each party, to some degree certain risks are completed outside the control of both parties" (Grimsey and Lewis 2004). If neither party is in a position of full control, the risk allocation should reflect how the private party 'prices' the risk and whether it is reasonable for government to pay that price, taking into the account the likelihood of the risk eventuating, the cost to the government if it retained the risk, and government's ability to mitigate any consequences if the risk materializes…essentially in risk allocation nothing is free." Grimsey and Lewis (2004) go on to state, "The private party estimates the project risks and their potential impacts on project revenues, and in effect sets premiums to insulate itself from the financial results of materialized results…the question for government is whether the risk premium is good value for money or whether it is more cost effective to accept the risk itself."
Akintoye et al. (2003) state that "transfer of risk is one method of achieving VfM, but based on an objective of optimal (rather than total) risk transfer. As a general rule, VfM can be expected

to increase initially as risk is transferred to the private sector until the optimum point is reached at which all risks have been allocated to the partner best able to manage them. Any further risk transfer will lead to a decline in VfM." Optimal risk allocation can be defined by the Equation 6.1 below:

$$\text{Public VfM}_{max} = \text{Bid Price}_{optimal} + \text{Value of Transferred Risk}_{optimal} \quad \text{(Eq 6.1)}$$

Figure 6.1 visually conceptualizes this theory of transfer of risks affecting the bid price and value for money. As the public asks the private to take on more risks, the bid price will increase but the overall exposure to risk to the public is diminished. Maximum Vfm is found where the risk allocation is balanced between the two parties that are best able to manage the risk and will provide the best VfM to the project.

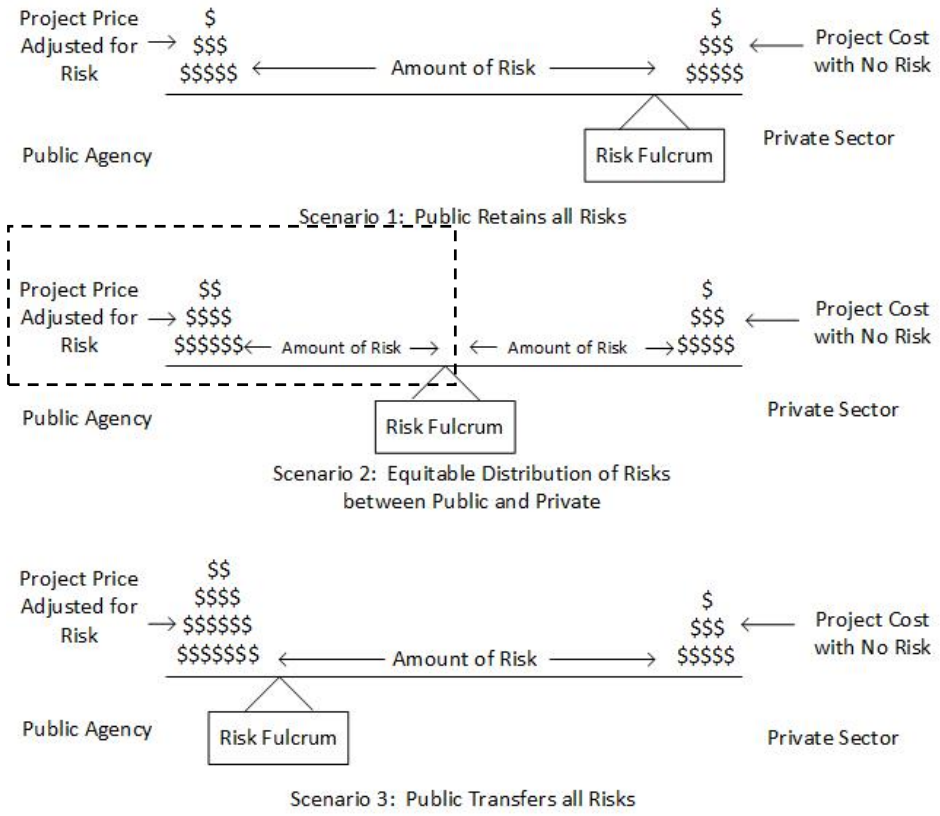

Figure 6.1: Illustrates how VfM is affected by Risk Transfer and Bid Price with three scenarios

Research Methodology

The study is a comparative analysis of the perception of risk of each stakeholder (public and private) in a P3 project. This study combines a content analysis of previous literature describing risk allocation in international P3 projects with structured interviews involving industry experts representing agencies and private companies with P3 project experience in the US. Figure 6.2 illustrates the research methodology and relates each research instrument to the point in the study where it was applied.

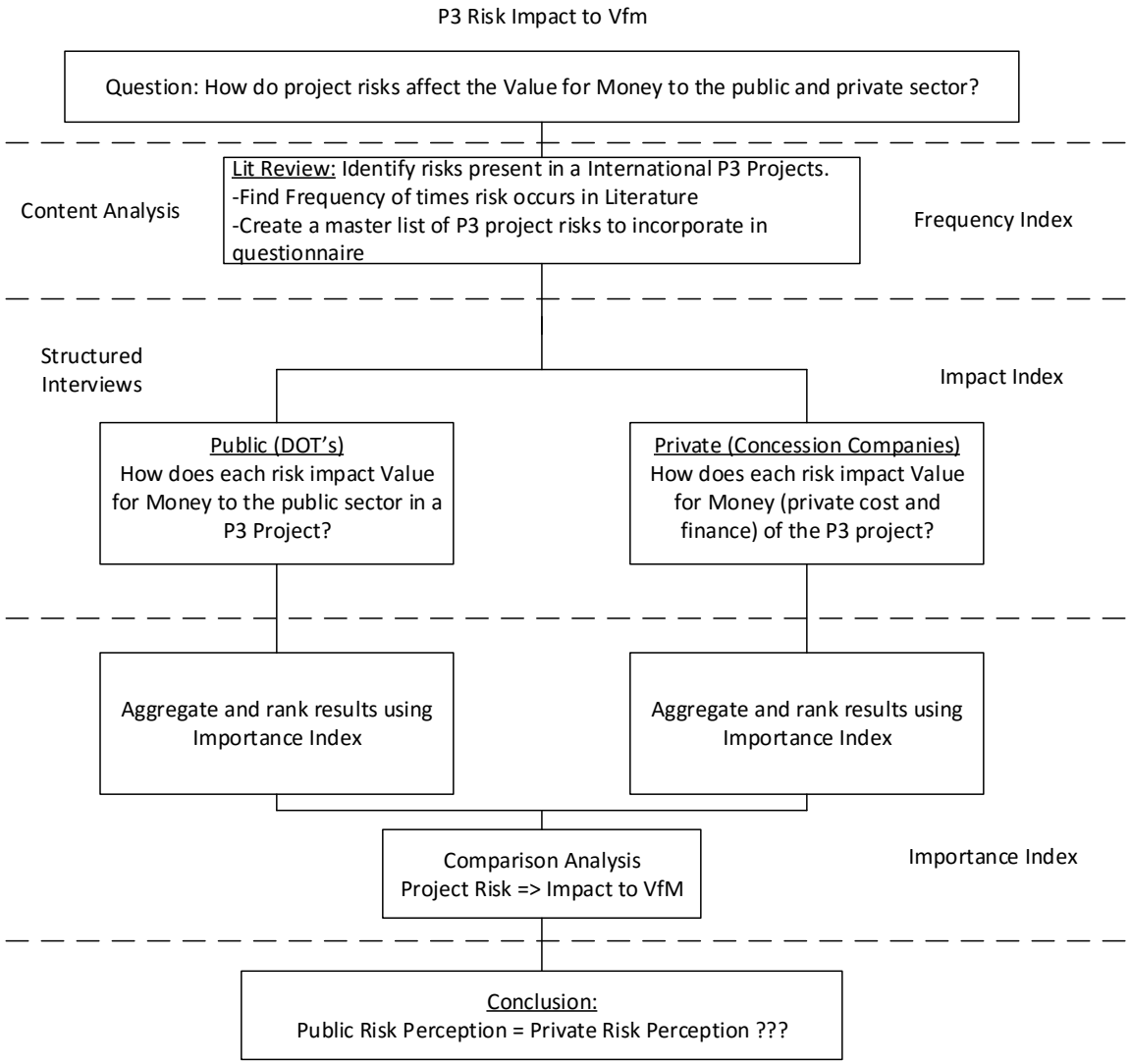

Figure 6.2: Research Methodology

The study first identified 21 top risks in P3 projects from review of previous literature on P3 project risks. Structured interviews were then conducted with state departments of transportation (DOT) and private concession companies with experience in P3 projects. The interviewee's were asked how each risk impacted value for money to the project, on a scale of

1. no impact,
2. some impact,
3. definite impact, or
4. extreme impact (possible no go decision).

An importance index was used to aggregate and rank the results to use for a comparative analysis.

Data Collection – Literature Review

Ke et. al (2009) performed a preferred risk allocation in China's P3 projects. Part of their research methodology was to identify risk factors in P3 projects by use of a content analysis of different risk allocation schemes from previous published literature on international P3's. "A comparative analysis of the different allocation schemes in Lam et al. (2007), Ng and Loosemore (2007), Li et al. (2005), Arndt (1998), Wang and Tong (2000), Victoria Department of Treasury and Finance (2001) and National Treasury of South Africa (2004) was conducted." This international study was used to identify risks present in P3 projects from previous literature and agency policy documents and was used as a foundation for this research project. The study consisted of 8 previous studies, six literary references (including their own) and two public agency documents relating to risk allocation in P3. This study added Virginia Office of Public Private Partnerships (VAP3) Risk Management Document published in 2015 (VAP3 2015) to

use as a public agency policy document to help calibrate P3 risk allocation in the US. A content analysis was performed on these documents referenced by Ke et. al (2009) in addition to VAP3's risk management document.

A total of 45 risks were identified in the nine different documents that reported on studies involving various factors of risk within a P3 project. Risks that did not apply to the US did not make the matrix as this study is limited to public infrastructure projects in the US so other international risks such as "unstable government" were not included on the risk matrix. Each time a risk was identified in the literature it was documented and placed on the content analysis risk matrix whose structure was adapted from Ke et al. (2009). The frequency of the risks occurring in the documents was quantified for each risk and placed in a separate column in the matrix. This was used to determine a master list of risks to be used for structured interviews in determining risk impact and to determine a frequency index of each risk. See Table 6.1 showing the results of the risk factors, the frequency of risks, and the frequency index.

Table 6.1: Risk Matrix Identifying Risk Factors in a P3 Project including Frequency (Adapted from Ke et al. 2009)

		Literature (Articles and Books)						Agency Published Documents				
Risk Category	Description	Arndt	Wang et al.	Grimsey et al.	Bing et al.	Lam et al.	Ke et al.	VDTF	NTSA	VAP3	Frequency	Freq. Index
		Aus	China	UK	UK	China	China	Aus	S.A.	US		
Political	Political Opposition				X		X		X		3	33.33
	Change in Law	X	X	X	X	X	X	X	X		8	88.89
	Unstable Government				X	X					2	22.22
	Government Project Approval	X		X		X	X	X		X	6	66.67
	Influential Economic Events				X			X			2	22.22
	Changes in industrial code of practice	X			X			X	X		4	44.44
Economic	Inflation Risk		X	X	X	X	X	X	X		7	77.78
	Interest Rate		X	X	X		X		X		5	55.56
	Foreign Currency Exchange		X				X		X		3	33.33
Design and Construction	Force Majeure	X		X	X		X	X	X	X	7	77.78
	Weather	X			X	X	X		X		5	55.56
	Improper Design	X	X	X	X	X		X	X	X	8	88.89
	Default of subcontractors	X	X		X	X			X		5	55.56
	Quality Risk	X	X	X	X	X		X	X	X	8	88.89
	Environmental Permitting	X	X		X			X	X	X	6	66.67
	Site Safety	X			X	X					3	33.33
	Availability of labor/materials		X		X	X					3	33.33
	Ground Conditions			X	X	X	X	X		X	6	66.67
	Site Availability	X		X	X	X	X	X		X	7	77.78
	Construction/Design Changes			X		X		X	X	X	5	55.56
	Labor disputes and strikes		X			X		X			3	33.33
	Land use			X	X				X		3	33.33
	Waste of materials	X		X	X					X	4	44.44
	Construction Cost Overrun	X	X	X	X			X	X	X	7	77.78
	Construction Completion	X	X	X	X		X	X	X	X	8	88.89
	Supporting Utilities Risk	X	X	X					X	X	5	55.56
	High Financial Cost	X	X		X		X		X		5	55.56
	Protection of geological and historical objects		X					X			2	22.22

Table 6.1 Continued

		Literature (Articles and Books)						Agency Published Documents				
Risk Category	Description	Arndt	Wang et al.	Grimsey et al.	Bing et al.	Lam et al.	Ke et al.	VDTF	NTSA	VAP3	Frequency	Freq. Index
		Aus	China	UK	UK	China	China	Aus	S.A.	US		
Operation & Maintenance	Operation & Maintenance cost overrun	X		X	X		X		X	X	6	66.67
	Operator Default	X	X	X				X			4	44.44
	Quality of Handback	X	X	X				X	X	X	6	66.67
	Frequency of Maintenance	X			X			X	X	X	5	55.56
	Low Operating Productivity	X	X		X				X		4	44.44
	Residual assets risk	X						X	X		3	33.33
	Condition of facility		X					X			2	22.22
Legal	Contractual Risk		X			X	X				3	33.33
	Third Party tort liability				X	X					2	22.22
	Ownership assets		X	X				X	X		4	44.44
	Insolvency of concession company		X						X		2	22.22
Market	Insufficient Income	X	X		X						3	33.33
	Fluctuation of material cost (government)		X	X				X	X		4	44.44
	Fluctuation of material cost (private)		X	X				X	X		4	44.44
	Market demand change	X	X	X	X		X		X		6	66.67
	Exclusivity		X					X			2	22.22
Other	Residual Risk			X	X		X				3	33.33

Table 6.1 was used to determine a final list of risks to include in a structured interview questionnaire to be evaluated with both the public and private sectors with experience in P3 highway projects in the US. The justification of selection of individual risk factors was if the risk occurred in 5 of the 9 publications listed on the matrix it was included on the master list of

risk factors with the structured interview questionnaire. The final list of risks include a total of 21 risks split into four main risk categories

- Political
    - Change in Law – Legislative Change
    - Government Project Approval
- Economic
    - Inflation Risk
    - Interest Rate
- Project Development (Design and Construction)
    - *Force Majeure*
    - Geotechnical and Subsurface Conditions
    - Land Acquisition
    - Environmental Permitting
    - Design Liability
    - Weather
    - Existing Utilities
    - Financial Costs and Availability
    - Construction Cost Overrun
    - Construction Schedule Completion
    - Design Changes during Construction
    - Default of Subcontractors or Suppliers
    - Quality
- Operations and Maintenance / Lifetime Phase

- Operation and Maintenance Cost Overrun
- Frequency of Maintenance
- Handback Requirements
- Demand and Revenue Below Anticipation

Data Collection – Structured Interviews

Structured interviews were conducted with 7 out of the 10 state DOT's with P3 experience on highway projects in the US in the last five years. The interviews were conducted January through March of 2016. At the time of the interview, there were a total of 20 highway projects in the US completed or underway using DBFM or DBFOM variations of P3 projects in the last five years. This was the scope of the population of experienced state DOT's. The representatives of the 7 DOT's interviewed comprised of 18 out of the 20 (90%) total highway projects completed DBFM or DBFOM in the US.

Structured interviews were conducted with 3 private concessionaires with P3 experience on highway projects in the US in the last five years. The private concessionaires interviewed are the majority equity partner within the private concession project team. These 3 private companies were equity partners on 9 out of the 20 P3 highway projects completed in the US using DBFM or DBFOM in the last five years. The 3 concessionaires accounted for over 60% of the total P3 project cost of all of these 20 projects completed nationwide.

The questions asked to both the public agencies and the private sector were;

1. Does your agency/company consider this risk?

2. How does each risk impact the value for money for the project? The impact was measured by 1 – No Impact, 2 – Some Impact, 3 – Definite Impact, or 4 – Extreme Impact (possible no go decision).

The comprehensive list of responses can be found in the appendix B. The results of the interviews were aggregated using the impact index.

Data Analysis – Importance Index

An Importance Index was used as a way to analyze the collected data through both the literature review content analysis and the structured interviews results. The method of calculating the Importance Index was derived from a similar method utilized by Assaf et. al (2005). The Importance Index has two components, a frequency component and a severity component, referred to in this study as impact. The frequency is measured by the Frequency Index and the impact is measured by the Impact Index.

Frequency Index (%) = $\sum$ (n/N) * 100 Eq 6.2

Where *n* is the frequency of responses or times the risk factor occurred in the literature, and *N* is the total number of responses or the total number of documents reviewed for content, in this case 9.

Impact Index (%) = $\sum$ a(n/N) * 100/4 Eq 6.3

Where *a* is the constant expressing the weight given to the response (1 – No impact , 2 – Some impact, 3 – Definite Impact, 4 – Extreme Impact (Possible No Go Decision), *n* is the frequency of the responses, and *N* is the total number of interviewees.

Importance Index (%) = [Frequency Index (%) * Impact Index (%)]/100 Eq 6.4

Comparative Analysis Results

The study is seeking to compare how individual risks impact value for money in a P3 project for both public agencies and private companies. By measuring the frequency and impact we are able compare project risks using the importance index. This will allow us to compare the level of importance given to each risk by both the public and private sector. Comparing the importance given to each risk will allow us to better understand the value each stakeholder (public and private) gives to each risk within a P3 project. Table 6.2 below shows the comparison results of each risk separated by public and private perception. The frequency, impact, and importance index results are included in this table and the risks are ranked with greatest importance to least importance.

Table 6.2: Risk Importance Ranking

DOT					Private Concession Company				
Public VfM					Private VfM				
Rank	Risk	Freq. Index	Impact Index	Import. Index	Rank	Risk	Freq. Index	Impact Index	Import. Index
1	Quality	88.89	52.04	46.26	1	*Force Majeure*	77.78	79.17	61.58
2	Geotechnical and Subsurface Conditions	66.67	67.86	45.24	2	Government Approval	66.67	89.58	59.72
3	Demand and Revenue Anticipation	66.67	67.76	45.18	3	Legislative Change	88.89	66.67	59.26
4	Inflation Risk	77.78	55.36	43.06	4	Environmental Permitting	66.67	87.50	58.34
5	*Force Majeure*	77.78	55.36	43.06	5	Construction Schedule Completion	88.89	54.17	48.15
6	Existing Utilities	55.56	75.00	41.67	6	Demand and Revenue Anticipation	66.67	69.79	46.53
7	Financial Costs and Availability	55.56	75.00	41.67	7	Geotechnical and Subsurface Conditions	66.67	64.58	43.06
8	Environmental Permitting	66.67	61.22	40.82	8	Land Acquisition	77.78	54.17	42.13
9	Government Approval	66.67	55.36	36.91	9	Operation and Maintenance Cost Overrun	66.67	62.50	41.67
10	Design Liability	88.89	38.27	34.02	10	Inflation Risk	77.78	50.00	38.89
11	Construction Schedule Completion	88.89	38.27	34.02	11	Design Liability	88.89	43.75	38.89
12	Construction Cost Overrun	77.78	42.86	33.34	12	Interest Rate	55.56	68.75	38.20
13	Legislative Change	88.89	36.73	32.65	13	Handback Requirements	66.67	52.08	34.72
14	Land Acquisition	77.78	40.82	31.75	14	Construction Cost Overrun	77.78	44.49	34.60
15	Handback Requirements	66.67	47.45	31.63	15	Existing Utilities	55.56	58.34	32.41
16	Interest Rate	55.56	55.10	30.61	16	Financial Costs and Availability	55.56	54.30	30.17
17	Operation and Maintenance Cost Overrun	66.67	39.80	26.53	17	Frequency of Maintenance	55.56	54.17	30.10
18	Frequency of Maintenance	55.56	44.39	24.66	18	Weather	55.56	50.00	27.78
19	Design Changes during Construction	55.56	39.80	22.11	19	Quality	88.89	30.55	27.16
20	Default of Subcontractors	55.56	33.67	18.71	20	Default of Subcontractors	55.56	37.50	20.84
21	Weather	55.56	29.34	16.30	21	Design Changes during Construction	55.56	31.25	17.36

"A risk may materialize in the course of a project. There is no guarantee that it would, but if it did, there would be a consequence." (Akintoye 2003) "There are two features that characterize risks, 1) the probability by which they can happen, and 2) their ultimate impact on the project if they do materialize." The two features of risk are probability of a risk occurring and the impact on the project if they do occur. Risks with high probability and high impact are typically identified as high priority. The relative importance index of risks from this study can help identify what risks are generally perceived as having high priority in P3 projects. Figure 6.3 and 6.4 graphs plot the frequency vs impact index for both the public and private sector. These figures graphically depict the level of importance with frequency on the x-axis and impact on the y-axis. Curves showing where the importance index is equal to 40 and 50 are plotted for comparison purposes.

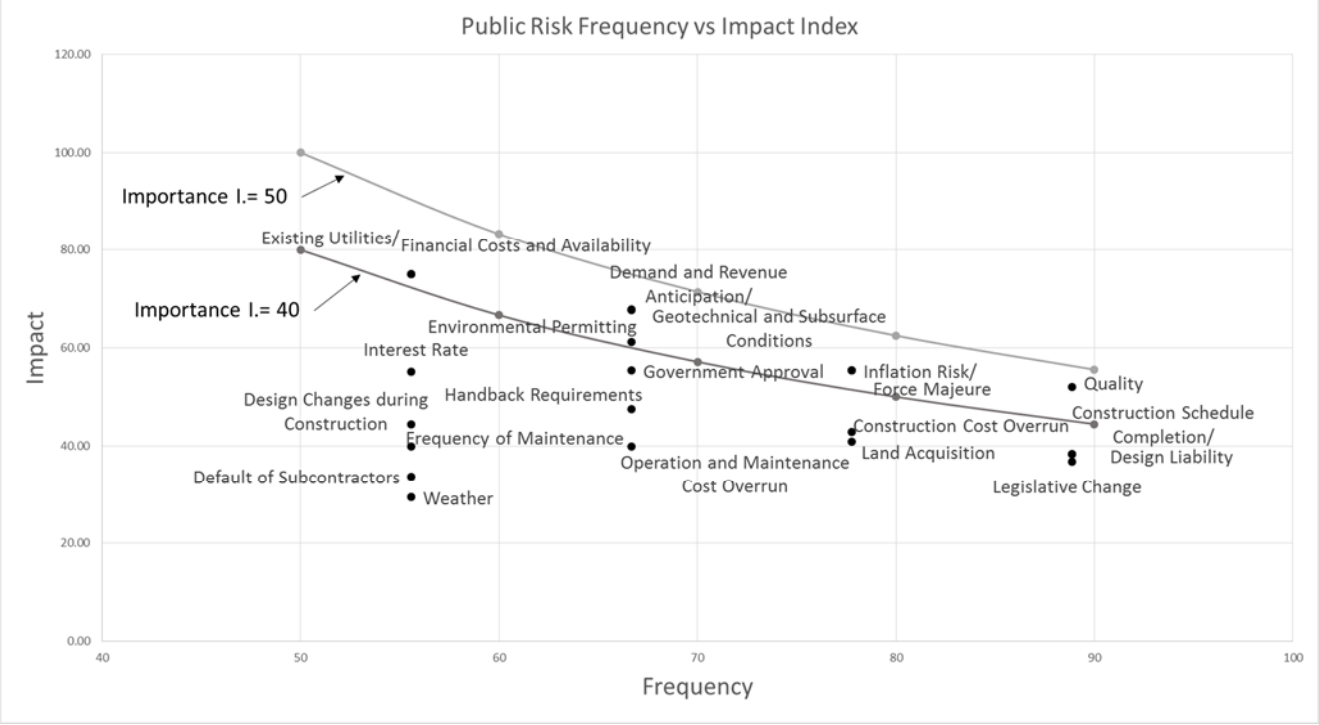

Figure 6.3: Public Risk Frequency vs Impact Index

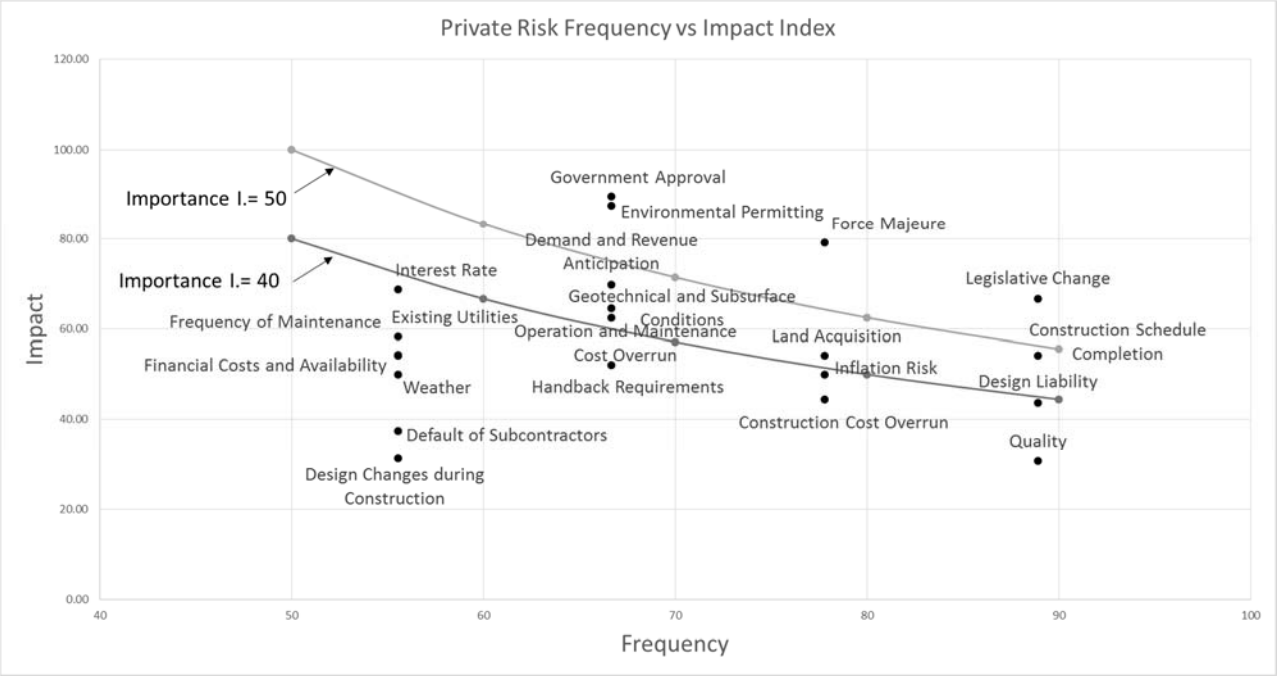

Figure 6.4: Private Risk Frequency vs Impact Index

These graphs visually show there are clear differences in how public agencies and private companies perceive risks in a P3 project. Four private risks are clearly identified as risks with high importance to the private sector within a P3 agreement, government approval, environmental permitting, force majeure, and legislative change. These risks represent possible show stoppers if asked to be completely transferred to the concessionaire. The private sector has a little, if any, ability to manage these risks and the cost premiums required to cover these risks greatly degrade project financial feasibility, potentially to the point where the concessionaire may decide not to pursue the project. These risks may be better suited to be managed by the public agencies. Grimsey and Lewis (2004) share this view, "generally speaking, those risks assumed by government are likely to include factors such as the risk of legislation or of a policy change discriminating against the project." Akintoye et al. (2003), "it was perhaps more straightforward to focus on those risks which should properly be retained by the public

sector…We need to consider the best way to handle risks which the private sector may not be best placed to control."

Conversely, the public agencies had no risks ranked above a 50 on the importance index, but did have a total of 8 risks ranked above a 40 on the importance index; quality, geotechnical and subsurface conditions, demand and revenue below anticipation, inflation, *force majeure*, existing utilities, financial costs and availability, and environmental permitting. Four of these eight publically perceived risks rank below 40 on the relative important index for the private companies; quality, inflation, existing utilities, and financial costs and availability. Thus those four risks represent an opportunity to accrue value for money to the public by transferring them to the private sector. "For a project to be successful, the differing needs of these parties must be met in the risk allocation process." (Grimsey and Lewis 2004)

VfM Assessment Framework

Chapter 5 and 6 have described how VfM in P3 projects can change as compared to different project delivery methods and the risk allocation of the project. Components of the framework being evaluated in these two chapters are;

- Value of design build efficiencies (Ch. 5)
- Value of private finance (Ch. 5)
- Value of private concessionaire providing long-term maintenance (Ch. 5)
- Value of risk transfer (Ch. 6)

The framework in figure 6.5 below illustrates a VfM assessment framework for P3 project delivery evaluation that combines these components with the overall process framework developed from Chapter 4.

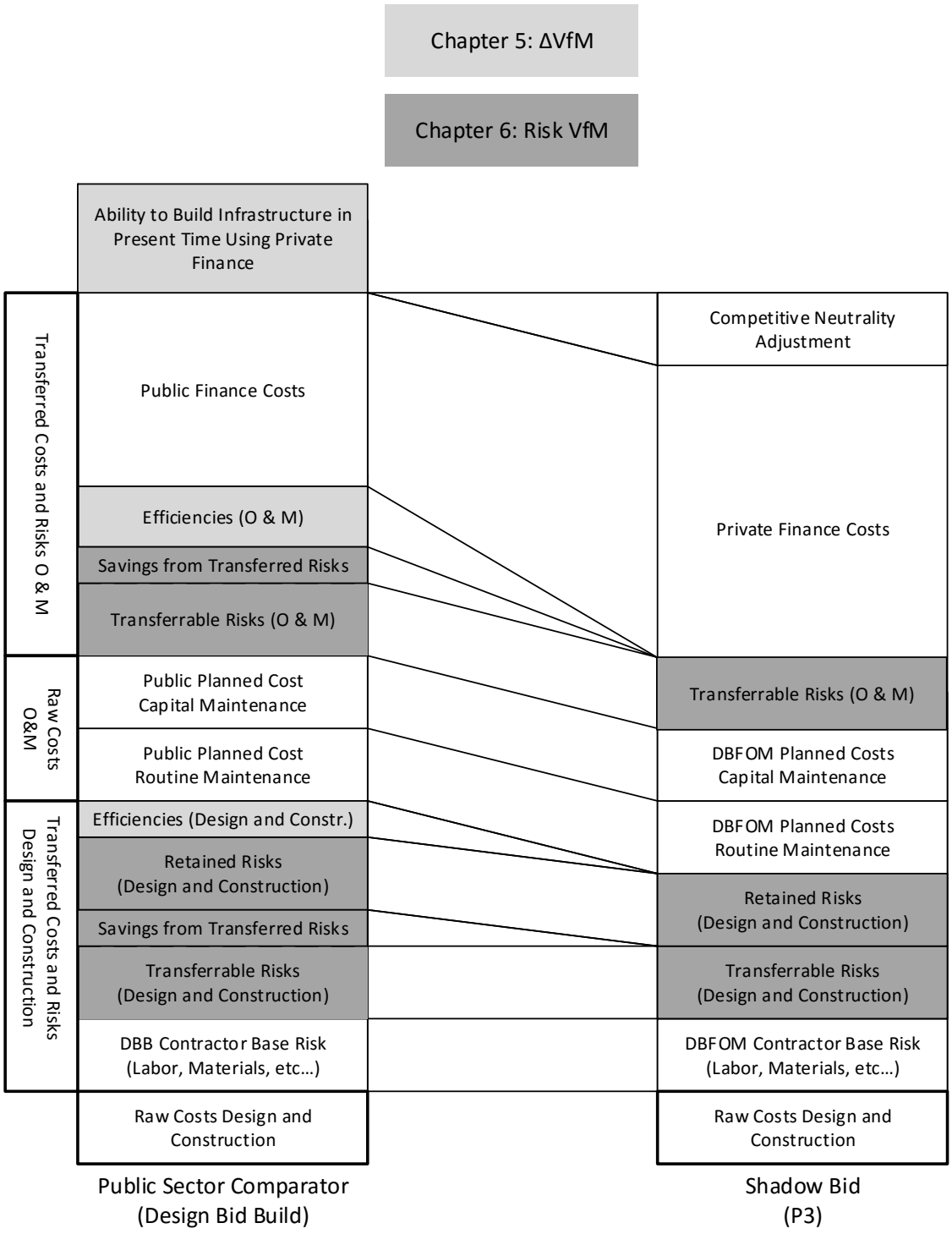

Figure 6.5: VfM Assessment Framework for P3 Projects

Conclusion and Discussion

As the need for funding of public infrastructure projects continues to grow in the United States so does the need to find alternative financing sources to provide more options for public agencies to provide much needed infrastructure. P3 project delivery provides an alternate method for public agencies to finance their projects. In order for the public agencies to provide the best possible value for money to the public, they must ensure the prospective P3 project has ample private sector competition. The attributes of the project must be attractive in order to draw interest from the private investors. Public agencies must balance the need to keep projects attractive to the private sector while maintaining good value for money to the public. The greater the risk, the greater the amount of risk premium, the greater the cost of the proposal to the public agency. Thus the aim of risk allocation within P3's is to find the balance between risk transfer and VfM.

How can public agencies allocate the risks within a P3 project to gain the most value of risk transfer while minimizing the increase of the price due to risk premium, thus maximizing the overall value for money to the public for the project? This research provides an insight to how each project risk generally affects the VfM within a P3 project to each stakeholder and can serve as a guide while 1) determining which projects to procure with P3 delivery, and 2) a starting point on allocating risks effectively within a P3 arrangement. This will allow agencies to find the right "fulcrum" of risk transfer to provide the best value for money for the project.

Limitations

Every project has its own unique risk profile and cannot be generalized across all P3 projects. Although this represents a large sample size of the population with experience in P3 projects, the perceptions of the agencies and companies interviewed may not represent the views of all stakeholder's of all P3 projects in the US.

Risk is something that is perceived by human beings. "Different risks will mean different things to different people. Some risks will even mean different things to the same people at different time in their lives or in different circumstances." (Akintoye et al. 2003) This study was based on perceptional risk within public agencies and private companies and perceptions of these risks may differ with different people at different times in different places.

CHAPTER 7
CONSOLIDATED CONCLUSIONS AND LIMITATIONS

As previously stated in Chapter 6, the *Report Card on America's Infrastructure* found that "32% of America's major roads are in poor or mediocre condition, costing U.S. motorists who are travelling on deficient pavement $67 billion a year, or $324 per motorist, in additional repairs and operating costs" (ASCE 2013) It seems FHWA (2015) is aware of this impact to road users' nationwide and has posted a national goal to "promote jobs and the economy, and expedite delays in the project development and delivery process." P3 project delivery offers public agencies an ability to utilize private resources such as private finance to better achieve the national goal to solve the problem stated by ASCE. As previously discussed, private finance is not free, as debt service costs money to the borrower, but many times the additional value of private sector involvement can not only offset but in some cases outweigh the cost of finance.

P3 project delivery involves the private sector in more project life cycle phases than traditional procurement, from the development phase though design and construction to, often times, operations and maintenance. VfM assessment allows agencies a way to compare project delivery from more of a project life cycle perspective. Determining VfM across a complex infrastructure project's life cycle is more complex than simply comparing construction bid prices with award to the lowest bidder. This research presents a framework agencies can use while performing VfM assessments to compare and justify the use of different project delivery methods including different scope and different contract durations. With P3 VfM there are not only design, construction, operations, and maintenance costs to quantify and include, but there is also the value of private finance to be evaluated versus traditional procurement VfM.

The research has identified there is value to the public user of having the ability to build an infrastructure project in present time rather than waiting for public funds to become available. Chapter 5 comparing VfM between P3 delivery in Pennsylvania and DB delivery in Missouri has shown the benefit of having infrastructure one year earlier with the involvement of private finance results in benefits to the road user of above $200 million. This benefit to the public user adds VfM to the public and should be included in the overall procurement evaluation. Chapter 5 has also identified efficiencies gained within both P3 and DB delivery methods in the bundling of multiple bridge replacements in one single contract for design and construction. This alternative contracting method has shown efficiencies gained through, 1) Pre-fabrication of materials, 2) Standardized design, 3) Reduced closure times, 4) Economies of scale. The overall value of the efficiencies gained through use of P3/DB was in excess of 6% in cost savings per bridge and resulted in approximately 50% time savings in construction days per bridge versus traditional procurement.

"Risk transfer is at the heart of structuring a P3 project." (Yescombe 2007) Chapter 6 explores how various project risks impact overall VfM within a P3 project to both stakeholders within a P3 arrangement, the public and private sector. The research has shown there are differing perceptions of the importance level of each risk within a P3 project. The private sector has indicated there are four specific project risks; government approval, force majeure, environmental permitting, and legislative change that could be unmanageable risks for them and could become show stoppers causing them to no longer pursue a project under P3. Public agency perception has identified some risks that are of high importance to them which the pivate sector deems as very manageable and most likely will not greatly increase the risk premium of

the project. These public high importance, private low to average importance risks may represent good VfM to the public agency if transferred to the private sector. The research included in Chapter 6 provides agencies with a good insight into how they can properly structure their P3 project risk allocation to receive the greatest VfM.

VfM assessment provides a rigorous rubric that permits public agencies to compare and justify both the benefit of developing new infrastructure projects and the preferred delivery method for the infrastructure project. The research provides a framework to use as a guide to identify and quantify the transfer of project risk, the benefits of DB efficiencies within a P3 project, the benefits of private finance, and the benefits of using the P3 concession team for long-term operations and maintenance. The framework can be used to assess the change in VfM if a project is delivered as a P3.

In addition to the research limitations stated in each of the papers contained in this thesis, it should be noted the VfM assessment framework and the components within the assessment framework have only been validated using a small sample size. As previously mentioned, there is little field data available for US P3 projects due to the recent advent of P3. This leads to a small sample size and very little historical data to be gathered to use for further validation. Much of the information contained in this thesis was gathered through perceptional structured interviews and the perceptions of the interviewees may not reflect all P3 projects in all situations the same.

CHAPTER 8
CONTRIBUTIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Chapter 8 discusses and highlights the importance of some findings and contributions drawn during the elaboration of this thesis. Furthermore, this chapter presents some recommendations for future research, which are intended to improve the VfM procedures proposed in this thesis.

Contributions

The main contribution of this thesis is the development of a VfM assessment framework public agencies can use while evaluating if an infrastructure mega-project should utilize a P3 project delivery and to provide some guidance to identify and quantify components of a VfM assessment such as,

- Value of DB efficiencies
- Value of private finance
- Value of using concession team for long-term maintenance
- Value of risk transfer

Additionally, other important contributions are mentioned below.

- *Additional Value in P3 Delivery:* Chapter 5 presents a comparative case study between P3 and DB project delivery of similar size, scope and complexity to identify quantitative and qualitative data and information to determine what the change in value for money is from P3 to DB project delivery. The study found:

- There is similar value present with DB efficiencies between DB and P3 when bundling numerous bridge replacements under one contract. Value was found in:
    1. Pre-fabrication of materials
    2. Standardized design
    3. Economies of scale
    4. Reduced closure times
- Additional value is found with including private finance in having the ability to build infrastructure in present time provides value to the public users of the infrastructure.
- Additional value of using the private concession team for long-term maintenance of the project comes in an increased design life of the infrastructure.

- *Value of Risk Transfer:* Chapter 6 presents identification and relative ranking of perceptional risk from the public and the private sector. This allows agencies some insight into how to properly structure risk allocation in a P3 project to garner the most value for money.

Recommendations for Future Research

Given the significant increase in the use of P3 techniques by state DOTs during the last few years, and the little existing research on the use of P3 delivery at a state level, it is expected, and even required, that there be an increase in the number of research projects as the one

comprised in this thesis. In the list below are some proposed research projects that may derive from this thesis:

- Agency life cycle cost data including development, design, construction, operations, and maintenance of infrastructure projects to improve the VfM assessment capability
- Comparative quantitative analysis on P3 O & M costs versus Traditional
- Quantification analysis of transfer of risk within P3 projects.
- Comparative analysis from parallel industry utilizing P3.

REFERENCES

Akintoye, A., Beck, M., Hardcastle, C. "Public Private Partnerships, Managing Risk and Opportunities." Blackwell Science, Ltd. Malden, MA. 2003.

Akintoye, A., Bing. L., Edwards, P., and Hardcastle, C. "Perceptions of Positive and Negative Factors Influencing the Attractiveness of PPP/PFI Procurement for Construction Projects in the UK." Engineering, Construction, and Architectural Management. Vol. 12, No. 2, pp. 125-148. 2005.

Arndt, R. "Risk Allocation in TH Melbourne City Link Project." The Journal of Structured Finance. 1998.

Assaf, S., Al-Hejji, S. "Causes of delay in large construction projects." Elsevier International Journal of Project Management. 2005.

American Society of Civil Engineers (ASCE) "2013 Report Card for America's Infrastructure," ASCE Reston, Virginia, p. 75-106. 2013.

Auditor General of Ontario. "Infrastructure Ontario – Alternative Financing and Procurement," 2014 Annual Report of the Office of the Auditor General of Ontario, 2014.

Buxbaum, J. and Ortiz I. "Public Sector Decision Making for Public-Private Partnerships." Vol. 391. Transportation Research Board, 2009.

Bing, L., Akintoye, A., Edwards, P., Hardcastle, C. "The Allocation of Risk in PPP/PFI Construction Projects in the UK." Elsevier International Journal of Project Management. 2004.

Brown, J., Pieplow, R., Driskell, R. Gaj, S. Garvin, M., Holcombe, D. Saunders, M. Seiders, J. Jr., and Smith, A. "Public-Private Partnerships for Highway Infrastructure: Capitalizing on International Experience," Report Number FHWA-PL-09-010, 2009.

Burger, P., and Hawkesworth, I. "How to Attain Value for Money: Comparing PPP and Traditional Infrastructure Public Procurement." OECD Journal on Budgeting, 11(1), 91. 2011.

Daniels, G., Stockton, W., and Hundley, R. "Estimating Road User Costs Associated with Highway Construction Projects, Simplified Method." Transportation Research Record 1732: Paper No. 00-0328. Transportation Research Board of the National Academies, Washington, D.C., 2005.

Davis, S., Diegel, S., and Boundy., R. "2012 Vehicle Technologies Market Report." Oak Ridge National Laboratory, 2013.

DeCorla-Souza, P. "New Tool to Understand Value-for-Money Analysis Concepts in Evaluating Public-Private Partnership Options," Transportation Research Record: Journal of the

Transportation Research Board 2450, Transportation Research Board of the National Academies, Washington, D.C., pp. 99-108. 2014.

Eisenhardt, K. "Building Theories from Case Study Research." Academy of management review, 14(4), 532-550. 1989.

ERIC/AE Staff. "Designing Structured Interviews for Educational Research." Practical Assessment, Research and Evaluation, 5 (12). 1997. http://pareonline.net/getvn.asp?v=5&n=12 [April 2, 2016]

FHWA. "Successful Practices for P3s, A Review of What Works When Delivering Transportation Via Public Private Partnerships." US Department of Transportation. March 2016.

FHWA. "Transportation Performance Management, TPM and MAP-21, National Goals." 2015. https://www.fhwa.dot.gov/tpm/about/goals.cfm

Flyvberg, B., Holm, M., Buhl, S. "Underestimating Costs in Public Works Projects: Error or Lie?" Journal of the American Planning Association, 68(3), 279-295. 2002.

Forbes, M. "$850m Transmission Gully Project Gets Green Light," www.Stuff.co.nz, downloaded 30 July 2015.

Gatti, U., Migliaccio, G., and Laird, L. "Design Management in Design-Build Megaprojects: SR 99 Bored Tunnel Case Study." ASCE Practice Periodical on Structural Design and Construction. Pp 148-158. February 2014.

Grimsey, D. and Lewis, M. "Public Private Partnerships, The Worldwide Revolution in Infrastructure Provision and Project Finance." Edward Elgar Publishing, Inc. Northampton, Massachusetts, USA. 2004.

Grimsey, D. and Lewis, M. "Are Public Private Partnerships Value for Money?" Accounting forum Vol. 29, No. 4, pp. 345-378. December 2005.

Garvin, M. "America's Infrastructure Strategy: Drawing on History to Guide the Future," KPMG LLP and Stanford University, Washington, D.C., 2007.

Garvin, M. "Public private partnerships for infrastructure: Forging ahead in America." LEAD 2008, Lake Tahoe, CA, 2008.

Garvin, M. "Enabling Development of the Transportation Public-Private Partnership Market in the United States." ASCE Journal of Construction Engineering and Management. April 2010.

Garvin, M. "International Practices in Public-Private Partnerships: Synthesis and Discussion." TR News, (274). 2011.

Gransberg, D., "Case Studies of Early Contractor Design Involvement to Expedite the Delivery of Emergency Highway Projects," Transportation Research Record No. 2347, Journal of the Transportation Research Board, National Academies, pp. 19-26. 2013.

Gransberg, D., Shane, J.,Strong, K., and Lopez del Puerto, C., "Project Complexity Mapping in Five Dimensions for Complex Transport Projects," Journal of Management in Engineering, ASCE, Vol.29, (4), pp. 316-326. October 2013.

Gransberg, D., and Molenaar, K. "Does Design-Build Project Delivery Affect the Future of the Public Engineer?" Transportation Research Record: Journal of the Transportation Research Board, No. 2081, Transportation Research Board of the National Academies, Washington, D.C., pp 3-8. 2008.

Gransberg, D., Scheepbouwer E., and Loulakis M. "Alliance Contracting—Evolving Alternative Project Delivery." No. Project 20-05, Topic 45-16. 2015.

Grimsey, D., and Lewis, M. "Are Public Private Partnerships value for money? Evaluating alternative approaches and comparing academic practitioner views." Elsevier Accounting Forum. 2005. Volume 29, Issue 4, pp 345-378. 2005.

Hale, D., Shrestha P., Gibson, E., and Migliaccio, G. "Empirical Comparison of Design/Build and Design/Bid/Build Project Delivery Methods." ASCE Journal of Construction Engineering and Management. 2009.

Hallmark, R., White, H., and Collin, P. "Prefabricated Bridge Construction across Europe and America." ASCE Practice Periodical on Structural Design and Construction. August 2012.

Harris, L.R. and Brown, G. "Mixing interview and questionnaire methods Practical Assessment." Research & Evaluation, 15 (1) p. 2. 2010.

Hawk, H. "Bridge Life-Cycle Cost Analysis (No. 483)." Transportation Research Board. 2003.

Heckman, D. "Taking Design-Build Statewide. Missouri's Safe and Sound Bridge Improvement Program." AASHTO Subcommittee on Bridges and Structures. 2012. http://bridges.transportation.org/Documents/SCOBS%20presentations%202012/Missouri's%20Safe%20and%20Sound%20Bridge%20Improvement%20Program.pdf

Herbsman, Z., Chen, W., and Epstein, W. "Time is Money: Innovative Contracting Methods in Highway Construction." ASCE Journal of Construction Engineering and Management. September 1995.

Hsieh, H. and Shannon, S. "Three Approaches to Qualitative Content Analysis." Qualitative health research, 15(9), 1277-1288. 2005.

Ibbs, C., Kwak, Y., Ng, T., and Odabasi, A. "Project Delivery Systems and Project Change: Quantitative Analysis." ASCE Journal of Construction Engineering and Management. 2003.

Infrastructure Australia. "National Public Private Partnership Guidelines Volume 4: Public Sector Comparator Guidance," Commonwealth of Australia, 2008.

Jin, X. and Doloi, H. "Interpreting risk allocation mechanism in public–private partnership projects: an empirical study in a transaction cost economics perspective." Construction Management and Economics 26.7 (2008): 707-721. 2008.

Ke, Y., Wang, S., Chan, A., Lam, P. "Preferred risk allocation in China's public-private partnership (PPP) projects." Elsevier International Journal of Project Management. 2009.

Lam, K., Wang D., Lee, P., Tsang, Y. "Modelling risk allocation decision in construction contracts." Elsevier International Journal of Project Management. 2006.

MacDonald, M. "Review of Large Public Procurement in the UK" London: HM Treasury. 2002.

Matthews, O. and Howell, G. "Integrated Project Delivery an Example of Relational Contracting." Lean Construction Journal 2005. Vol 2 #1 April 2005.

McCarthy, I., & Anagnostou, A. "The Impact of Outsourcing on the Transaction Costs and Boundaries of Manufacturing." International journal of production economics, 88(1), 61-71. 2004

Melton, L, and Dilley, C. "Public Sector Asset Management: Roundtable Report." RICS, London, http://www.rics.org/Global/RICS_PSAM_040416_dwl_aa.pdf, [April 4, 2016]40pp. 2016

Michigan Department of Transportation. "Construction Congestion Cost." 2016. http://www.michigan.gov/mdot/0,4616,7-151-9625_54944-227053--,00.html

Miller, M.C. and Gransberg, D.D. "Integrating Social Impact to Bridge Asset Management Plan," Infrastructure Asset Management. Vol. 1, No. 1, March 2015.

Miller, C., Rueda-Benavides, J., and Gransberg, D. "Applying Social Return on Investment to Risk-Based Transportation Asset Management Plans in Low Volume Bridges," Transportation Research Record No. 2473, Journal of the Transportation Research Board, National Academies, pp. 75-82. 2015

Molenaar, K., Harper, C., Yugar-Arias, and I. "Guidebook for Selecting Alternative Contracting Methods for Roadway Projects: Project Delivery Methods, Procurement Procedures, and Payment Provisions." Next-Generation Transportation Construction Management Transportation Pooled Fund Program Study TPF-5(260). 2014.

Molenaar, K., Songer, A.., and Barash, M. (1999) "Public-Sector Design/Build Evolution and Performance." ASCE Journal of Management in Engineering. March/April 1999.

Moralles, D, Amekudzi, A., Ross C., Meyer M. "Value for Money Analysis in U.S. Transportation Public-Private Partnerships." Transportation Research Record: Journal of

the Transportation Research Board No. 2115, Transportation Research Board of National Academies, Washington, D.C., pp 27-36. 2009.

Office of the Minister of Finance, Office of the Minister of Transport. "Enabling the Procurement of Transmission Gully Using a Public Private Partnership," report to the Cabinet Economic Growth and Infrastructure Committee, New Zealand, 2012.

Oppenheim, A. "Questionnaire Design, Interviewing and Attitude Measurement." Continuum, London. 1992.

National Audit Office. "Examining the value for money of deals under Private Finance Initiative." Report by the Comptroller and Auditor General. HC 739 Session 1998-99. August 1999.

National Infrastructure Unit of the Treasury (NIU). "Guidance for Public Private Partnerships (P3s) in New Zealand," version 1.1., NZ Treasury, 2009.

National Treasury of South Africa. "National Treasury PPP Manual." 2004.

NZ Treasury. "Current Discount Rates," downloaded 30 July 2015, http://www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/currentdiscountrates.

Virginia Public Private Partnerships. "P3 Risk Management Guidelines." The Commonwealth of Virginia. March 2015.

Virginia Office of Transportation Public-Private Partnerships (VAP3). "PPTA Value for Money Guidance," Commonwealth of Virginia, 2012.

Virginia Office of Transportation Public-Private Partnerships (VAP3). "Risk Assessment for Public-Private Partnerships," Commonwealth of Virginia, 2012.

Owens, J., Ahn, J., Shane, J., Strong, K., and Gransberg, D. "Defining Complex Project Management of Large US Transportation Projects: A Comparative Case Study Analysis," Public Works Management and Policy, Vol. 16 (4), October 2011.

Shrestha, P., Migliaccio, G., O'Connor, J., and Gibson, E. "Benchmarking of Large Design-Build Highway Projects. One-to-One Comparison and Comparison with Design-Bid-Build Projects." Transportation Research Record, 1994(1), 17-25. 2007

Silberston, A. "Economies of Scale in Theory and Practice." The Economic Journal, pp. 369-391. 1972.

Touran, A. and Wiser, E. "Monte Carlo Technique with Correlated Random Variables." Journal of Construction Engineering and Management, 118(2), 258-272. 1992.

U.S. Department of Transportation, Federal Highway Administration. (2006). "Design-build Effectiveness Study." 2006. (http://www.fhwa.dot.gov/reports/designbuild/designbuild.pdf) (April 2, 2007)

Victoria Department of Treasury and Finance. "Partnerships Victoria." 2001

Wang, S., Tiong, R., Ting, S., Ashley, D. "Evaluation and Management of Political Risks in China's BOT Projects." ASCE Journal of Construction Engineering and Management. May/June 2000.

Weaver, S. and Weston, F. "Strategic Financial Management, Applications of Corporate Finance." Thomson South-Western. Canada. 2008.

Weber, R. "Basic Content Analysis." Sage Publications, Inc. Beverly Hills, California. 1985.

Williams, T. "Predicting Final Cost for Competitively Bid Construction Projects Using Regression Models." International Journal of Project Management, 21(8), 593-599. 2003.

World Bank. "Value-for-Money Analysis – Practices and Challenges: How Governments Choose when to Use P3 to Deliver Public Infrastructure and Services," The World Bank, Washington, D.C. 2013.

Yeo, K., & Tiong, R. "Positive Management of Differences for Risk Reduction in BOT Projects." International Journal of Project Management,18 (4), 257-265. 2000.

Yescombe, E. "Public-Private Partnerships: Principles of Policy and Finance." Elsevier Ltd. 2007. Butterworth-Heinemann, Burlington, MA. 2007.

Yin, R. "Case Study Research, Design and Methods." Sage Publications. 1994. Thousand Oaks, California. 1994.

APPENDIX A - CHAPTER 5 SUPPLEMENTAL

	Safe and Sound Project		Rapid Bridge Replacement	
Question Description	MoDot	KTU	PennDot	Plenary
What do you think Value for Money is?	Quantitative	Qualitative	Quantitative	Quantitative
	Qualitative	Quantitative	Qualitative	Political/social functional definition
		Internal functional definition		
		Political/Social definition		
Which of the following were reasons for selecting the project delivery method?	Improvement to Bridge System, to be performed quickly	N/A	Bundling Approach to decrease # of structural deficient bridges	N/A
			Minimizing disruption to traffic	
			Take advantage of funding	
Which of the following ways do you believe resulted in project cost savings?	Economies of Scale (Tie-1)	Closure of Bridges (1)	Economies of Scale (Tie-1)	Standardized Designs (1)
	Pre-Fabrication Facility (Tie-1)	Economies of Scale	Pre-Fabrication Facility (Tie-1)	Economies of Scale
	Standardized Designs (Tie-1)	Pre-Fabrication of Materials	Standardized Designs (Tie-1)	Pre-fabrication Facility
	Maintenance of Traffic Costs	Standardized Designs		Minimizing Mobilizations
	Time Value of Money	Minimizing Mobilizations		Closure of Bridges
	Closing of the Bridges to save time of construction	Crews with improved efficiencies		
		Subcontracting of bridges to work simultaneously		
		Timing of the contracts (Supply/Demand)		
Which of the following ways do you believe the project experienced a shortened project duration?	Pre-Fabrication Materials (Tie-1)	Pre-Fabrication of Materials	Overlapping of Design and Construction	Pre-Fabrication of Materials
	Standardized Designs (Tie-1)	Overlapping of Design and Construction (Close 2nd)	Pre-Fabrication of Materials	Overlapping of Design and Construction
	Experienced Crews with improved efficiencies (Tie 1)	Increased collaboration	Standardized Designs	Standardized Designs
	Overlapping of design and construction	Standardized Designs	Experienced crews with improved efficiencies	Experienced Crews with improved efficiencies
	increased collaboration	Experienced crews with improved efficiencies	Incentivized contract completion	Subcontract to other subcontractors
	Reduced unanticipated schedule impacts	Cash Incentive		
		Closing of Bridges		
Which of the following ways do you believe the project was able to reduce the amount of bridge closure time?	Standardized Designs (Tie-1)	Designing in reduced Closure Time	Planning Dashboard used as a checklist	Pre-Fabricated materials
	Contract Incentives (Tie-1)	Increased collaboration	Experienced crews with improved efficiencies (Close 2)	Designing in reduced closure time
	increased collaboration	Pre-Fabrication of Materials	Pre-Fabrication of Materials	Standardized design
	Designing in reduced closure time	Standardized Designs	Standardized Designs	Experienced crews with improved efficiencies
	Pre-Fabricated Materials	Experienced crews with improved efficiencies	Designing in reduced closure time	Installation of activities before bridge closure
	Experienced Crews with improved efficiencies	Installation of activities before bridge closure		
What are the benefits of replacing the bridges in present time?	Do not need to place load restrictions on bridges impacting local economy	Do not need to place load restrictions on bridges impacting local economy	Do not need to place load restrictions on bridges impacting local economy	Do not need to place load restrictions on bridges impacting local economy
		State cannot exceed a certain # of structural deficient bridges	Reduce Fuel Consumption (Not overwhelming)	Projects can be built now
		Public Safety	Increase Air Quality (Not overwhelming)	Public Safety
				Inefficient Maintanance $$$, Maintaining of bad bridges
				Reduce Fuel Consumption (Not overwhelming)
				Increase Air Quality (Not overwhelming)
What are the benefits of involving the private sector with the finance of the project?	N/A	N/A	Ability to replace the bridges in present time	Life Cycle, higher quality and lowering NPV
			Higher standard of quality bridges, pay more now but higher quality of lifetime (100 year bridges)	Financial Expertise
				Ability to replace bridges in present time
				Cost certainty
				Only pay if it works
What are some of the benefits of having a long-term maintenance agreement with the Concession group that designed and built the project?	N/A	N/A	Transfer of risk, if something is wrong with the bridge, one entity	Life Cycle Innovation
			Life Cycle Innovation (Close 2)	Cost certainty
			Cost Certainty	Maintenance not subject to politics

APPENDIX B – CHAPTER 6 SUPPLEMENTAL

State Department of Transportations - Public Private Partnership Risks

Objective: To understand how each risk Impacts the Value for Money to the Public Sector in a P3 Project

Risk Category	Risk				
Political					
	Change in Law - Legislative Change				
	Do you consider this Risk?	Yes	7	No	0
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		6			1
	Government Project Approval				
	Do you consider this Risk?	Yes	7	No	0
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5	2.5	3		
Economic					
	Inflation Risk				
	Do you consider this Risk?	Yes	7	No	0
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	0.5	4.5	2		
	Interest Rate				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	1	5		
Project Development (Design and Construction)					
	Force Majuere				
	Do you consider this Risk?	Yes	7	No	0
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	0.5	4.5	2		
	Geotechnical and Subsurface Conditions				
	Do you consider this Risk?	Yes	7	No	0
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		2	5		
	Land Acquisition (Right of Way)				
	Do you consider this Risk?	Yes	5	No	2
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	3	3		
	Environmental Permitting				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		3	2	2	
	Design Liability				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5	5.5			
	Weather				
	Do you consider this Risk?	Yes	5	No	2
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2.5	4.5			

	Existing Utilities (Known and Unknown)				
	Do you consider this Risk?	Yes	7	No	0
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	5	1	
	Financial Costs and Availability				
	Do you consider this Risk?	Yes	7	No	0
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		2	3	2	
	Construction Cost Overrun				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	5	1		
	Construction Schedule Completion				
	Do you consider this Risk?	Yes	5	No	2
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	3	1	1	
	Design Changes during Construction				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	4	1		
	Default of Subcontractors or Suppliers				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	3	4			
	Quality				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	3	2	1	
O & M Lifetime Phase					
	Operation and Maintenance Cost Overrun				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	4	1		
	Frequency of Maintenance				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5	3.5	2		
	Handback Requirements				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5	2.5	3		
	Demand and Revenue Below Anticipation				
	Do you consider this Risk?	Yes	6	No	1
	How Much Impact does this Risk have on the Final Value for Money?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1		4.5	1.5	

Private Concessionaire - Public Private Partnership Risks					
Objective: To understand how each risk Impacts the Private VfM (Cost and Finance) of a P3 Project					
Risk Category	**Risk**				
Political					
	Change in Law - Legislative Change				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	1	1	
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	Government Project Approval				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
			0.5	2.5	
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1		0.5	1.5	
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2		0.5	0.5	
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2		0.5	0.5	

Economic					
	Inflation Risk				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1		2		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	3				
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	3				
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	3				
	Interest Rate				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
			3		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	1	1		
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			

Project Development (Design and Construction)					
	Force Majuere				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1		2	
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		2		1	
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		2		1	
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		2		1	
	Geotechnical and Subsurface Conditions				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
			3		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	Land Acquisition (Right of Way)				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	1		1	
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			

	Environmental Permitting				
	Do you consider this Risk?	Yes	3	No	
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
			1	2	
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	1	1	
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	1	1	
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	1	1	
	Design Liability				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	1	1		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	3				
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	Weather				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		2	1		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	3				
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			

	Existing Utilities (Known and Unknown)				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	2		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	Financial Costs and Availability				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	0.5	2		0.5	
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	0.5	2		0.5	
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5	1		0.5	
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5	1		0.5	
	Construction Cost Overrun				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	0.5	2.5			
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2		1		
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2		1		
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2		1		
	Construction Schedule Completion				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	1.5	1		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2		1		
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2		1		
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2		1		

	Design Changes during Construction				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	1.5			
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	3				
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	Default of Subcontractors or Suppliers				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	3				
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	Quality				
	Do you consider this Risk?	Yes	2	No	1
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	1	1		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			

O & M Lifetime Phase					
	Operation and Maintenance Cost Overrun				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	0.5		2.5		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5		1.5		
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5		1.5		
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	0.5	1	1.5		
	Frequency of Maintenance				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	0.5	1	1.5		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5	1	0.5		
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1.5	1	0.5		
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	0.5	2	0.5		
	Handback Requirements				
	Do you consider this Risk?	Yes	2	No	1
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1		2		
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	2	1			
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
	1	2			
	Demand and Revenue Below Anticipation				
	Do you consider this Risk?	Yes	3	No	0
	How Much Impact does this Risk have on the Project Cost (Insurance, Contingency, Higher Markup)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	1.5	0.5	
	How Much Impact does this Risk have on the Equity Return on Investment (% of IRR)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	2		
	How Much Impact does this Risk have on the Debt (% of Debt Service)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	2		
	How Much Impact does this Risk have on the Debt-to-Equity Ratio (% of Equity/Debt)?				
	No Impact	Some Impact	Definite Impact	Show Stopper	No Opinion
		1	1.5	0.5	

APPENDIX C - INSTITUTIONAL REVIEW BOARD

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 2/1/2016

To: Phil Barutha
2711 South Loop Drive Suite 4700
Ames, IA 50010

CC: Dr. Douglas Gransberg
394 Town Engineering

From: Office for Responsible Research

Project Title: Master's Thesis - Risk Evaluation in a Public Private Partnership

The Co-Chair of the ISU Institutional Review Board (IRB) has reviewed the project noted above and determined that the project:

☐ Does not meet the definition of research according to federal regulations.

☒ Is research that does not involve human subjects according to federal regulations.

Accordingly, this project does not need IRB approval and you may proceed at any time. We do, however, urge you to protect the rights of your participants in the same ways you would if IRB approval were required. For example, best practices include informing participants that involvement in the project is voluntary and maintaining confidentiality as appropriate.

If you modify the project, we recommend communicating with the IRB staff to ensure that the modifications do not change this determination such that IRB approval is required.