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W117 Readers & Friends,

2017 has been an amazing year for W117. The Procurement experts in the Netherlands have been using the Best Value Approach (BVA) PIPS successfully. The BVA PIPS has moved to Norway where the first large project has been awarded. Dr. Dean has moved into Poland and motivated the Polish Best Value Foundation to have their first official training. The Saudi Arabian Classification Group has put the BVA information system into their classification system. The JSS University in Mysore, India has decided to move the BVA education and research into their university.

I have officially retired from Arizona State University (ASU) to become more involved in the effort as a full time researcher/coordinator for W117. As described in the W117 roadmap, working commission W117 has become the most successful working commission in impacting the industry and the academic research community. The working commission's performance metrics seem "unbelievable" (Table 1).

Table 1: Performance Metrics of W117

$17.6M in Research Funding	1,900 Research Tests Conducted
33 States in the USA	$6.6B of Services Delivered
90% Customer Satisfaction	1,000+ Professional Presentations
50 Refereed Journals, Conference Papers and books	
52 Intellectual Property (IP) Licenses issued by Arizona State University. [Most licensed technology at the most innovative university in the U.S. (U.S. News and World Report)].	

The Best Value Approach (BVA) technology is the most significant and innovative intellectual property (IP) coming out of academic research in the construction management area addressing procurement, risk management and project management. The IP includes a deductive logic model called the Information Measurement Theory (IMT), a New Procurement Model, a New Risk Management Model, a New Project Management Model and the Optimization of the Supply Chain processes.

By observation, and documentation (see *"W117 Performance Information in Construction: 2017 Research Roadmap Report"* and *"A New Approach to Impacting the Construction Industry"*) there are two major problems in the construction industry and the academic research community:

1. Academics do not agree with each other, and despite intensive literature searches, do not know what other researchers are doing. They tend to reference sources that agree with their conclusions.

2. The academic research community and the construction industry are in impenetrable silos.

One of the difficulties of W117 is to successfully expose the research results of W117. Many researchers have no knowledge of the dominant results. One can ask: how can a research group change the procurement approach of a developed country like the Netherlands, and not be referenced by other researchers in the same research areas (procurement, project management and risk management)? W117 research results are unique due to the approach of using academic research/industry testing with documented results. The results are *not* opinions or results of the analysis of opinions, but actual test results. By observation, researchers desire to be non-biased and do complete literature searches, but somehow tend to miss dominant research. The majority of their conclusions are what they "believe" to be accurate (Charlier, S.D., et al 2011).

The construction industry, its stakeholders and academic researchers are in silos. The construction industry does not value what the researchers publish, because they don't implement what the researchers propose, and the researchers do not add value to the industry, marked by documented evidence. The silos have to be broken down.

As the editor of the W117 journal, I propose that a major objective of our group is to break through this non-transparent academic and industry environment with the following actions:

1. The journal will emphasize academic research/industry tests and results. The journal will publish case study after case study of academic research/industry tests. This will break down the silos between academia and the industry because the tests will be conducted by both parties.
2. This journal will have to put the dominant information "on the street" with great speed (two months after submittals). If the information takes more than six months to get to researchers, it will probably not be used.
3. The peer review will be done by experts in the area of the IP and research work. Peer reviewers actions will be monitored and measured by W117 staff.
4. The journal will need to have an "amplification of exposure." To accomplish this, a "totally free" platform which is used by a large number of professors, will have to be identified. Then the W117 papers will be posted for free. As soon as the journal is published, all papers will be loaded on the ResearchGate.com platform, where over 12M researchers participate.

We will then have increased transparency. In the first year of this action, **5,000 hits** were received on the W117 papers. This is an increase from under 100 in the previous years; the traditional environment was not transparent. It was an academic world structured after the "Emperor Who Has No Clothes." Academic researchers were using relationships to build up their resume and perceived value, with very little value. In this non-transparent environment, valuable and non-valuable work cannot be differentiated. The research results seem complex, and the industry cannot use the results. If transparency can be created, the simplicity of the results will lead the industry to change. This journal will create simplicity and transparency in the academic research community and the construction industry. For further information, please

read the papers *"W117 Performance Information in Construction: 2017 Research Roadmap Report"* and *"A New Approach to Impacting the Construction Industry."*

This journal includes the new W117 Roadmap, the "New Approach to Academic Research," one case study from a BVA implementation in the Netherlands, a survey identifying the state of the procurement system in Saudi Arabia, and three papers on value of projects, delay factors, corruption and non-transparency.

W117 has also been tasked to introduce two other CIB research roadmaps (*"W120: Disasters and the Built Environment"* and *"TG72: Public Private Partnerships"*), which are attempting to provide transparency to assist and motivate the industry to change. The two research roadmaps are listed immediately after this letter.

Safe summer and a successful rest of the year.

Professor Dean Kashiwagi
P.E., PhD, Fulbright Scholar, IFMA Fellow
W117 Journal Editor


Dean T. Kashiwagi


Jacob Kashiwagi


David Gastélum

Sources

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W120 – Disasters and the Built Environment: Research Roadmap

CIB Commission W120 – Disasters and the Built Environment, in collaboration with UNISDR – The United Nations Office for Disaster Risk Reduction – published a Research Roadmap focussing on how research can contribute to the planning for, and the design, construction and management of a built environment that has a maximum resilience against disasters.
The publication can be downloaded for free here.

Dr Wim Bakens, CIB:
"If a city has ambitious resilience goals, the needed approach will be far reaching and of a challenging complexity. It requires the development and implementation of and experimentation with new concepts and technologies and research has a major role to play in this. With this research roadmap CIB hopes to show the international research community how it can be most effective in supporting society as a whole to become more resilient. We hope that this publication will help and in fact stimulate both national and international research funding agencies, research institutes and research dissemination organisations in Building and Construction to define the right priorities and to do this in a worldwide cooperation."

Dr Jerry Velasquez, UNISDR:
"The cooperation between CIB and the United Nations Office for Disaster Risk Reduction (UNISDR) Campaign, "Making Cities Resilient: My City is getting ready!" have been useful in the development, and will be useful in the implementation and follow-up of various global agreements, in particular in reducing disaster risks and addressing disaster risk factors in the built environment."

The Research Roadmap has been largely drawn from a series of the webinars. The webinars shared knowledge and expertise between CIB members, the United Nations Office for Disaster Risk Reduction (UNISDR), and cities that are involved in the UNISDR's 'Making Cities Resilient' Campaign. The target audience for the webinars were local governments, disaster risk reduction practitioners, planners and researchers. The webinars were jointly organised by CIB and the UNISDR and provided an important international and multi-disciplinary forum for discussing key research ideas and agendas related to disasters and the built environment. There were four such webinars on different topics, including:

1) Enabling risk reduction through urban planning.
2) Engaging multiple stakeholders in DRR for cities.
3) People's needs and expectations in post-disaster reconstruction.
4) Making Cities Resilient campaign local government self-assessment tool.

Draft versions of the Research Roadmap were presented for stakeholder consultation at various international conferences, at which the domain of 'resilience of the built environment' was addressed.

The focus of the Research Roadmap is on:

- Institutional, managerial and legislative mechanisms.
- The role of private sector.
- Engagement of built environment professionals.

Contact Information

Earlier published CIB Research Roadmaps and Roadmap Consultation Reports can be downloaded here.

Detailed description of CIB Commission W120 – Disasters and the Built Environment can be seen here.

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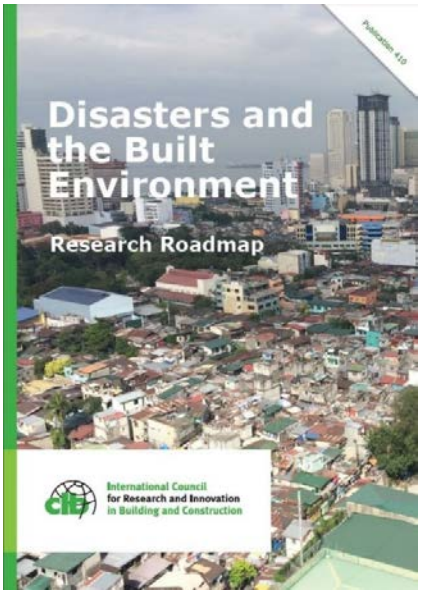

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TG72 – Public Private Partnerships: Research Roadmap

Under the responsibility of CIB Task Group TG72 – Public Private Partnerships, Akintola Akintoye and Mohan Kumaraswamy authored the newest CIB Research Roadmap. The publication can be downloaded for free here.

Background

Public-Private-Partnerships (PPPs) are joint ventures, in which business and government cooperate; each applying its strengths to develop a project to deliver public services more quickly, more efficiently or otherwise better than a government could accomplish on its own. Significant synergies are expected from combining public and private sector resources, while safeguards are also needed to avoid risks of any abuse of the necessarily closer working arrangements and relationships.

This research roadmap report highlights a number of significant challenges for PPP, along with some areas needing particular attention and further study. It also presents a number of positive innovative opportunities with some potential ways forward.

Diversity

There are various types of public–private partnerships being used in different parts of the world and for different projects. While in some countries Design-Build-Finance-Operate (DBFO) is popular for their Private Finance Initiative (PFI) projects, other PPP modalities used world-wide are special turnkey contracts, perpetual franchises, BOT, BOOT, BTO, lease-purchase, lease-develop-operate, sale and leaseback etc.

Each of these approaches can offer distinct advantages to clients or private sector actors, often depending on the specific social, economic, political and regulatory environment. In addition, there are diverse drivers for PPP development, different practices and varying degrees of success of PPPs across countries. Indeed, these differ, not just from place to place, but also from time to time, given periodic shifts in needs, agendas and priorities along national development trajectories. As in any such comparison, there is value in adapting relevant lessons learned to applicable scenarios, so as to shorten learning curves or avoid similar mistakes e.g. in selecting PPP modes, protocols and partners.

Research

There is still much to learn about PPP in relation to its drivers, policy framework, financial context, institutional framework, organisational structure, scope, limitations, changes in its applications, risks and potential benefits over time with future development. There is also much research to be undertaken in order understand these issues, which are categorised under seven research themes:

1) Financing, and financial models and structure.
2) Risk allocation and management.
3) Transparency and accountability including regulatory and institutional frameworks.
4) Public policy and private/public sector behaviours.
5) Ppp project evaluation.
6) Contractual structure. And ppp performance indicators.

Contact Information

Information about CIB Task Group TG75 can be obtained here, or by contacting its joint Coordinators. Information about the concept of the CIB Research Roadmap can be obtained here. This section of the CIB Website includes links to all available and free downloadable Research Roadmaps.

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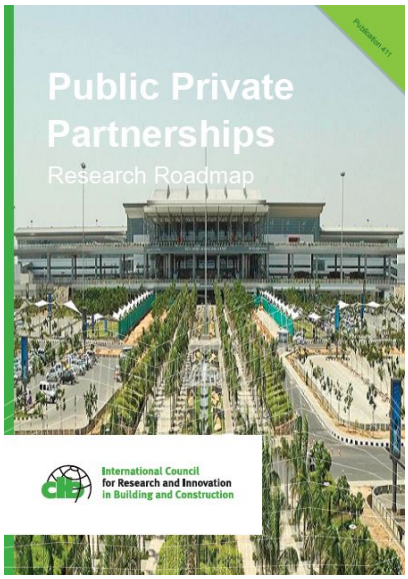

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W117 Performance Information in Construction: 2017 Research Roadmap Report

Foreword: by Dr. Wim Bakens-Secretary General for CIB

The CIB Working Commission W117, "Performance Measurement in Construction," is one of the more innovative and productive research-based commissions in CIB. It focuses on the utilization of performance metrics in the delivery of construction services. The home for W117 is the Performance Based Studies Research Group (PBSRG) at Arizona State University (ASU) in Tempe, Arizona, where W117 and ASU-PBSRG hold their annual Best Value Conference. From its start in 2009, W117 was led by Prof. Dean Kashiwagi (ASU), and his group of innovators (Dr. Kenneth Sullivan, Sylvia Romero, John Savicky and Dr. Jacob Kashiwagi) and co-coordinator, Professor Charles Egbu, (Glasgow Caledonian University). In 2016, W117 was joined by Co-Coordinator Prof. Sicco Santema, (University of Technology, Delft, Netherlands) the visionary who led to the proliferation of the W117 technology in the Netherlands.

W117 aims to change construction procurement and stakeholder organizations worldwide through the use of the information-based Best Value Approach (BVA). As such, it differs from most CIB Commissions that are more science driven, while W117 is more concept and impact driven. It has been one of the most successful CIB Commissions in bridging the gap between the construction industry practice and academic research. It has been prolific in publishing and running research tests with industry partners. W117 and PBSRG have published over 300 papers and generated licensed technology (47 licenses from AZTech, the licensing body of ASU for intellectual property rights). It is the most licensed technology from the most innovative university in the U.S. (as rated by U.S. News and World Report (2016).

W117 is responsible for the development and continuous testing of the following technologies:

1. Best Value Approach (BVA).
2. Best Value (BV) technology.
3. Performance Information Procurement System (PIPS).
4. Performance Information Risk Management System (PIRMS).
5. Information Measurement Theory (IMT) and Kashiwagi Solution Model (KSM).
6. A new project management model based on IMT.
7. A new risk management model that focuses on the risk that the expert vendor does not control.

The activities of WII7 are responsible for the following unique and dominant impacts on the delivery of construction:

1. Rijkswaterstaat, the largest user of construction services in the Netherlands, won the 2012 Dutch Sourcing Award (DSA) for the successful completion of a $1B infrastructure project called "fast-track projects" using BV-PIPS.

2. NEVI, the Dutch procurement professional organization, has licensed the Best Value technology from ASU and has identified the approach as a mainstream approach to the delivery of services, educating and certifying procurement professionals in the delivery of construction and other services.
3. Dutch visionary and author Sicco Santema, and his protégé Jeroen Van de Rijt, published a Best Value Procurement (BVP) Dutch book, using Dutch test cases to show the BVA technology was compliant with European Tender Law (12,000 books sold). Other books (in Dutch) were also published for the contractor community.
4. RISNET, a Dutch risk management association, licensed the Best Value Approach in order to increase the use of the risk-based project management in the construction industry.
5. W117 BVA certification system was developed, which certifies competence of BV professional practitioners.
6. W117 coordinator, Dr. Kenneth Sullivan, introduced the BVA into Canada, resulting in $3M research grants for the delivery of construction services in 25 different universities and government organizations.
7. W117/PBSRG Best Value expert John Savicky, signed a sole source agreement with the National Association of State Procurement Officials (NASPO) and their subsidiary, the Western States Contracting Association (WSCA), to allow all states to utilize the W117/PBSRG technical expertise by "sole source." This has led to tests in 33 different states.
8. Introduction of BV into Malaysia in 2012, into the Project Management Master's Program, led by Dr. Fah Choy Chia at Universiti Tunku Abdul Rahman (UTAR).
9. Introduction of BV into India in 2014 resulting in the noted engineering school, SJCE, adopting the curriculum into their engineering school.
10. Introduction of BVA into Norway in 2014, through the FIR, the construction engineering association. FIR also translated the Dutch book into Norwegian, going public on June 20, 2016, during a three-day event to include the first certification of Best Value professionals in Norway. The first BVA testing occurred in 2016 [with the award made in 2017], and with a minimum of five additional tests scheduled in 2017. The first large BVA certification testing sponsored by W117, occurred in 2017 in Trondheim, Norway. Earlier individual certifications occurred in 2014 and 2016.
11. Introduction of BV into Poland with a three-day conference in Krakow in March 2016, with the publication of the translated Dutch Best Value Procurement (BVP) book into Polish. The first W117 sponsored certification training occurred in April 6, 7th 2017 with the licensed Polish BV Foundation. The next BVA CIB sponsored training will be in October 2017.
12. Introduction activities in Switzerland, Denmark, Finland, Hungary, Germany and Saudi Arabia in 2015 and 2016.

These research efforts have led to the following future research and development opportunities:

1. Development of the language of metrics in the delivery of construction services.
2. The development of a new risk management and project management models.
3. Opportunity to test the sustainability of innovation in traditional environments.
4. Opportunities to test the innovative concepts in different countries.
5. Opportunity to identify and test the sustainability of testing new theoretical concepts in the industry without the traditional extensive academic research literature search and investigations.

W117 has successfully utilized the CIB Platform to impact the construction industry performance worldwide with the information based academic research. Its drive to make a difference is to be applauded and this Research Roadmap (for consultation) is one more example of its high quality and high impact deliverables.

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Dr. Wim Bakens (Secretary General)
The CIB Board

Remarks by the W117 co-chairs:

The W117 commission is a leader in innovation. It is the first commission to have a very focused goal of implementing academic research/industry testing to impact the construction industry. The research is constantly evolving and impacting the direction, scope and speed of evolution of performance metrics, transparency, mitigation of risk and the improvement of the supply chain stakeholders. However, this is not the only thrust and value of W117. The W117 is looking to change the definition of successful and impactful research from traditional academic/industry

research. It will change what is recognized as valuable and impactful research. This Research Roadmap is the latest document, as of June 2017, and will be continually changed in the coming years. W117 welcomes all other working commissions and industry visionaries to join in the effort towards improving the construction industry.

Towards a CIB W117 Research Roadmap

In 2005, the CIB Program Committee organized TG61, for the purpose of identifying the performance of the construction industry based on performance information or metrics. TG61 produced a report based on a comprehensive literature research on the use of performance metrics in the construction industry. It identified a lack of research based on actual industry research tests (Egbu et. al., 2006). As a recommendation of TG61, the CIB Program Committee established a Working Commission, W117, on the *Use of Performance Information in Construction* in 2009, and appointed Dean Kashiwagi (Arizona State University) and Charles Egbu (Glasgow Caledonian University) as co-chairs. In 2016, Charles Egbu was replaced by Sicco Santema (Delft University of Technology).

W117 Objectives and Scope

The objectives and scope of W117 is to document and explore the potential use of performance information to improve the state of all stakeholders and their organizations in the construction industry supply chain. This includes:

1. To establish W117 as the worldwide center of excellence in both the construction industry and in academic research in the documenting, doing theoretical, prototype testing, implementation research and the testing of performance information to create transparency and the mitigation of risk in the construction and other industries.
2. To identify collaborators who could assist the W117 in the documentation, testing and research of the use and implementation of construction performance information in the industry.
3. To improve supply chain performance and the performance of all stakeholders in the construction industry through research and testing.
4. To advocate the use of performance metrics in the acquisition and delivering of construction work.
5. To advocate for new approaches to performance metrics that improves the construction industry performance.
6. To study different countries and cultures to identify how the use of performance metrics can improve the performance of construction and other services in their respective countries.
7. To document the use, research and testing of performance metrics in the delivery of services in the *Journal for the Advancement of Performance Information & Value*.
8. To quickly and accurately get the W117 research results to the industry and stimulate even more research in the area of performance metrics by utilizing the W117 journal.
9. To apply different approaches of research to validate outcomes from different angles. Approaches include literature search, discussion among the industry and academic

researchers, and analyzing the opinions of individuals interviewed on the concept of using deductive logic and common sense and hypothesis testing. All of which are validated by immediate testing in practice.

W117 Work Program

The W117 Work Program includes:

1. Conduct research on the use of performance information in the construction industry to develop state of the art practices that increase construction performance and value, minimize risk and resolve longstanding issues in the construction industry.
2. Test all concepts in academic research/industry tests, which are led by visionary researchers. The use of research/industry test results to validate new concepts to change the way research is perceived.
3. Publishing a CIB preferred journal to document the use and impact of performance information in the construction industry and quickly disseminate to the industry and research community.
4. Hold annual CIB W117 meeting, to discuss the latest results of research in the use of performance information in construction.
5. Do CIB W117 webinars or post presentations on youtube to proliferate the exposure of the use of performance information concepts in the construction industry.
6. Attend and participate in different international conferences to stimulate expert discussion on the use of performance metrics in the construction industry.
7. Partner with different research groups and industry experts to proliferate research on the use of performance metrics.
8. Educate and run academic/research tests in different countries to the use of performance metrics in the delivery of construction.
9. Hold W117 meetings to assist different countries in implementing performance metrics in the delivering of construction services.
10. Hold meetings with industry stakeholders to help bridge the gap between academic research and industry practices and encourage the industry to sponsor academic research testing on their own projects.
11. Generate research funding to do research in the use of performance metrics in the construction industry.
12. Create partnerships with active research groups and the CIB to self-fund CIB W117 activities and research and can be self-sustainable without CIB funding.

Introduction

The CIB Secretariat has created a CIB Roadmap that will assist the working commissions to create their own roadmaps, to become successful, sustainable, focused on a strategic plan and assist the improvement of the worldwide construction industry, see Figure 1. The CIB research roadmaps provide authoritative guidance and support for national and international research bodies and funding agencies.

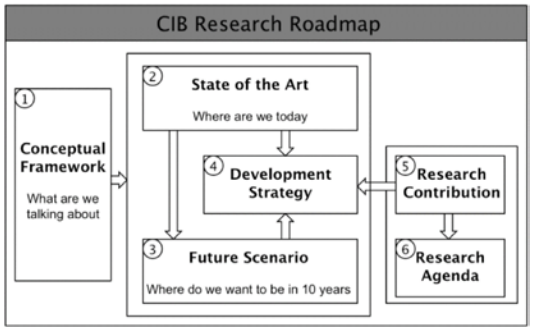

Figure 1: Outline of Research Roadmap

As the illustration indicates, creating a CIB 117 Research Roadmap requires the following questions to be addressed:

1. Conceptual Framework:
   What are we talking about? This question includes the typical: What are the issues, how are these interrelated, what influences all of this, who are the stakeholders, what are the relevant areas of expertise, what are the characteristics of relevant systems, processes, and technologies? This is addressed in the *Conceptual Framework* section.

2. State of the Art:
   Where are we today? This question includes: State of technology, best practices, international variations, perceived problems and the world's leading centers of expertise. The state of the art is elaborated in the section *State of the Art in the Utilization of Performance Information*.

3. Future Scenario:
   Where do we want to be in ten years? The stakeholders' vision is described in section *Future Scenario: Where Do We Want to Be in Ten Years?*

4. Development Strategy:
   This section includes: what is needed in terms of knowledge, information, tools, concepts and applications to enable the respective systems, processes and technologies to be developed over time? These subjects will be described in the section *Development Strategy.*

5. Research Contribution:
   In section *Research Contribution,* we describe how W117 research contributes to the development strategy and what the requirements for research are in order to make that contribution.

6. Research Agenda:
   Section *Research Agenda* concludes with the agenda for W117 research worldwide. That will include areas of science and technology development, required sequences of development, priorities, international cooperation within the research community, cooperation between research and practice.

Conceptual Framework

W117 Research Technology: The Use of Performance Metrics in the Construction Industry

The conceptual framework for TG 61 and W117 was created by co-chair Dean Kashiwagi (Arizona State University) and supported by Charles Egbu (Glasgow Caledonian University) and later, Professor Sicco Santema (Delft University of Technology). Professor Dean Kashiwagi is a researcher in the area of performance metrics, the language of metrics and the use of metrics to simplify and improve the construction industry performance. He has had research test responsibilities for more than 25 years. His expertise is defined by over 300 publications, 1,900 research tests and delivery of $6.6B of services. He also has been involved with education and research testing in 13 countries [United States, Canada, Finland, Botswana, Democratic Republic of the Congo, Netherlands, Malaysia, India, Norway, Poland, Vietnam and China] and 34 states in the United States. This led him to being named as an original co-chair of W117, and resulted in the conceptual framework for W117 research. Professor Charles Egbu gave W117 tremendous support in exposing the performance information technology in the UK academic conferences. Professor Sicco Santema has been the latest visionary to support the worldwide effort.

Co-chair Dean Kashiwagi has gone through multiple cycles of finding new researchers in the area of utilizing performance metrics for the improvement of construction services. The cycles were needed because many of the participating researchers, after a certain time period, did not sustain or receive enough funding in the W117 research area to stay active in this narrow field of W117 research. Dr. Dean has been successful in recruiting new W117 members within the same area of expertise to replace those who moved on to other research areas. The new members are being recruited not only from academia, but from the industry as well, many who are running research tests in different countries. The research tests are continually improving and developing the *technology of performance metrics* (Best Value Approach, language of metrics logic called the Information Measurement Theory, procurement processes, project management processes and risk management processes).

Worldwide construction research was mainly focusing on the documentation of problems. This included the documentation of Key Performance Indexes or KPIs. However, the research community has failed to show how the KPIs increased the performance of construction services. For example, many industries use KPIs but do not know how to apply the metrics to improve construction performance. Each country also has their own perception of the cause of the construction industry non-performance.

In 1993, ASU/PBSRG identified a potential solution. It had the following unique characteristics:

- Based on deductive logic identified as Information Measurement Theory.
- Simplification of the environment and creation of transparency.
- Identification of industry experts who could immediately test the hypothesis.
- PBSRG maintains a high level of control over the industry test.

Issues in the Construction Industry Worldwide

Worldwide, the construction industry has had performance issues for the past 30 years. It appears to be a low performing industry; clients are unhappy and construction projects do not finish on time or on budget and construction companies finish projects at a loss. Over the last 30 years the assertions were validated by numerous landmark studies. The first major study was a breakthrough study conducted in 1994 by Sir Michael Latham (1994), who identified how significant non-performance was attributing to the continued failings within construction in the United Kingdom. He was one of the first researchers to expose that construction non-performance has been existent for the past 30 years. Interestingly, Peter Goff, of the International Project Management Association (IPMA), shares a similar argument by identifying that, despite the hundreds of millions of dollars invested by private enterprises and government to increase education and training of project managers, there has been no major increase in performance to back up its validity (Goff, 2014). In all, Latham identified current business practices of management, direction and control as the causes of an inefficient environment, and non-performance on construction projects (1994).

Due to the continuous efforts of resolving construction non-performance, the industry was still not improving. In 1997, the United Kingdom commissioned John Egan to develop a task force to perform another study on the performance of the industry. Similar to the first study, Egan identified a lack of leadership in business practices and integration of standard processes and teams (Egan, 1998). Although both studies have motivated industry and academia to improve the industry performance, the construction industry has seen minimal improvements moving into the 2000's to present day (Chikuni & Hendrik, 2012; Oyedele et al., 2012; Georgy et al., 2005; Bernstein, 2003).

The construction industry has continued to struggle in the 2000s, though some improvement has been documented. The UK, from 2000 to 2011, saw an increase in customer satisfaction from 63% to 80%, but its projects were still only completing on time 45%, and met budgets 63% of the time (KPI REF). In the U.S., productivity has decreased by 0.8% annually (Adrian, 2001). Construction companies have the second highest failure and bankruptcy rate of 95% (Associated General Contractors, 2006). Over 90% of transportation construction jobs are over budget, and almost 50% of time is wasted on job sites (Lepatner, 2007).

According to a recent Construction Industry Institute (CII) study published in 2015, 2.5% of projects are defined as successful (scope, cost, schedule, and business), 30% of projects completed within 10% of planned cost and schedule, 25 to 50% is wasted due to coordinating labor on a project, and management inefficiency costs owners between $15.6 and $36 billion per year (Lepatner, 2007; PWC, 2009; Yun, 2013).
In 2008, TG61 did a comprehensive literature review of all research efforts worldwide to identify:

1. Research groups who identified the issue of construction nonperformance, and ran academic/industry research tests to confirm their hypothesis.
2. Research groups who ran repeated academic/industry research tests to validate their hypothesis to increase construction performance.

The study filtered through more than 15 million articles and reviewed more than 4,500 articles. The study found only 16 articles with documented performance results. The Best Value Approach (BVA) was one of three construction methods found in those articles, and the Best Value Approach was found in 75% (12 of 16) of the articles (Egbu, et al., 2008; Michael, et. al., 2008). The BVA was identified as the only research concept with repeated performance metrics.

For the past five years, W117 has been attempting to identify all construction delivery systems with documented performance information. W117 has sifted through hundreds of papers, websites, and personal industry contacts, and found similar results to the first study. Thus far, the only approach with documented performance is the BVA and PIPS. (Thomas, and Napolitan, 1995; Odeh, and Battaineh, 2002; Hsieh et al., 2004; Assaf, and Al-Hejji, 2006; Arain, and Pheng, 2006; Lo et al., 2006; Sambasivan, and Soon, 2007; Al-Kharashi, and Skitmore, 2009; Mahamid, et al., 2011; PBSRG, 2016)

In one promising study, Sanvido and Konchar identified that the design-build approach was significantly better. However, five years later, a follow-up and more comprehensive study identified that there was no significant evidence that one approach was better to any of the other approaches (Leicht, 2015; Konchar, 1998).

A conceptual framework was proposed by Kashiwagi (1991) that has remained as the foundation of the efforts of W117 (Figure 2).

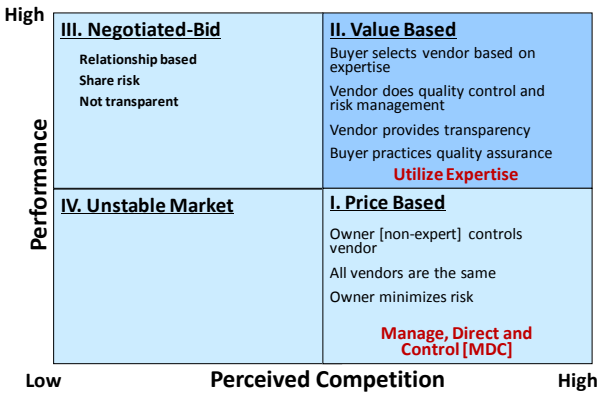

Figure 2: Conceptual framework of the construction industry structure

The Construction Industry Structure has the following proposals:

1. Poor performance is caused by owners using management, direction and control (MDC) to minimize the risk of construction nonperformance.
2. Risk is caused by non-expert stakeholders and not contractors [over 90% of all project cost and time deviation (US Army Medical Command study, State of Minnesota study and Rijkswaterstaat fast track projects)].
3. Risk cannot be transferred by means of contracts.
4. When MDC is utilized to mitigate risk; risk, cost and nonperformance increases.
5. High-performing construction is delivered by utilizing construction expertise instead of MDC.

W117 has proposed the following to the construction management research community and the construction industry based on research test results (Kashiwagi J., 2013; Kashiwagi, D., 2016; PBSRG, 2016):

1. The owner or buyer of construction is one of the biggest sources of risk in the delivery of nonperforming construction.
2. Management, direction and control (MDC) by the owner to minimize the risk of construction nonperformance is a major source of nonperforming construction.
3. The lack of utilization of construction expertise by the owners of construction is a resulting problem.
4. The lack of the quantification of construction problems using performance metrics has resulted in the construction nonperformance being a stubborn and lingering problem.
5. There is confusion in the construction industry on the source of construction nonperformance.

W117 conceptualizes the current problem of construction nonperformance with the following characteristics:

1. The construction academic researchers and industry sees the industry as being too complex and has difficulty simplifying the problem and potential solutions.
2. Because of the lack of understanding of the construction nonperformance, it is very difficult to identify the problem, devise a system/approach to solve the problem, and run tests to validate the proposal.
3. The industry perceives that the problem is a technical problem, and is therefore looking for technical solutions such as BIM to solve their problems. W117 research has identified the problem as a non-technical problem, and more related to the supply chain and humanistic characteristics of the supply chain stakeholders.

W117 proposes to solve the problem by using:

1. Deductive logic, natural laws, transparency and simple concepts.
2. Utilizing expertise to lower cost and improve quality.
3. Creating transparency by creating simplicity using the language of metrics.
4. Creating simplicity by changing the definition of risk as what an expert does not control, changing the project management and risk management model [utilizing a weekly risk report (WRR and Director's Report)].

Test results over the past twenty years have validated many of these concepts. For example:

1. When transparency is created, there a very few disagreements between stakeholders.
2. When an expert has a plan that includes the functions of all stakeholders, the stakeholders do much better in minimizing the risk that they would normally maximize.

3. When performance metrics are used, there is minimal discussion on someone's level of expertise.
4. An expert who knows what they are doing should always have a lower price than a non-expert. Therefore, the objective is to hire an expert who can lower project costs.

A study was performed, identifying that the Best Value PIPS was the only delivery system with the concept of no-control or minimizing management, direction, and control (Kashiwagi J., 2013). This research also documented the potential impact that implementing the concept of no-control could have on the delivery of construction services (Kashiwagi J., 2013). The study involved 31 construction and non-construction services, among 5 different major buyers in the U.S., comparing the performance of the project when delivered with the Best Value no-control concept and with the traditional management, direction and control techniques (see Table 1). It found the following:

- Cost of services decreased on average by 31%.
- Suppliers were able to offer the buyer 38.5% more value, totaling up to $72.76M.
- The average customer satisfaction of the service being provided increased by 4.59 points on a 1-10 scale (134% greater than the traditional customer satisfaction rating).

Overall Comparison

Criteria	Traditional	Best Value
# of Outsourced Services	31	31
Cost of Services	$274,480,342	$189,001,943.00
Added Value	-	$72,762,248.60
Average Customer Satisfaction	3.43	8.02

State of the Art in the Utilization of Performance Information

PBSRG, Kashiwagi Solution Model (KSM) Inc., W117, TU-Delft and the JSS, have been developing the use of performance information in the construction industry for the past 25 years. The state of the art practices, which are the most licensed technology developed at Arizona State University (licensed by Arizona Tech, the licensing arm of Arizona State University) include:

1. Using the Best Value Approach (BVA) to deliver construction services which results in a very high level of performance. This includes the use of the Performance Information Procurement System (PIPS) and the use of the Performance Information Risk Management System (PIRMS). PIPS has three major phases: Selection, Clarification and Execution. PIRMS uses the low-bid award system as the selection phase, but the clarification and execution phases are identical.
2. The use of the language of metrics to create transparency. The language of metrics minimizes misunderstandings through unified coding.

3. The identification that risk is caused by non-expert stakeholders. Risk cannot be passed. Risk has to be mitigated. Performance metrics are used to explain risk to non-experts, thus leading to risk mitigation.
4. The use of Information Measurement Theory (IMT) and the Kashiwagi Solution Model (KSM) to understand human nature, predict future human behavior and utilize these technologies in the selection and alignment of human resources in construction services.
5. The optimization of construction resources using a structure that assists in the optimization of expertise by creating an environment of transparency.
6. Continuous learning from tests and new versions of the methodology. The cycle of learning keeps speeding up as more countries and academics/practitioners are joining the effort.

The W117 sponsored journal captures the latest developments in the use of performance information in the construction and other industries. W117 also keeps a database of published papers in the area of performance information. The W117 committee members are constantly experimenting by using the BVA in new environments (including different industries and countries).

The technology of the Best Value Approach (BVA) is licensed by Arizona State University to 52 organizations and is used by supply chain stakeholders (owners, designers/engineers, facility managers, contractors, subcontractors and material suppliers) and academic researchers. The BVA has led to a new project management model including a new risk management approach (risk can only be mitigated and not transferred) and a new leadership approach which utilizes the entire supply chain.

The CIB W117 Performance Information in Construction working group, is led by the creator and founder of the BVA and includes the worldwide experts in both academic research and construction industry practice in the area of using performance metrics in construction projects. W117 is constantly looking for new countries and contributors (both in practice and in academia) who understand the Information Measurement Theory (IMT) and urge them to participate with W117.

The case of the Netherlands adoption of the BVA took five years. These years included the usage of BVA by Rijkswaterstaat on the $1B U.S. fast track road construction projects, the acceptance of BVA by NEVI (Dutch professional procurement group) and the publishing of the first Dutch Best Value Procurement (BVP) book (by Jeroen van de Rijt and Sicco Santema). This book showed that the methodology was compliant with the European Tender Law. Up to 2016, the book is in its third edition and more than 12,000 copies of that book have been sold in the Netherlands. As an example of continuous development, the fourth edition of the book will be published in 2017, adopting all the latest insights.

In the Netherlands, now that the BVA has great exposure, the challenge becomes:

1. How to ensure that the new paradigm is being understood by new practitioners.
2. To ensure proper documentation.

3. To ensure that the contractors/vendors understand the BVA.
4. How to educate the supply chain fast enough to keep up with the demand of Best Value services.

W117 is now faced with the challenge of how to proliferate the BVA in the other European countries. Currently BVA has been moved into Norway and Poland, having the Dutch book translated into Norwegian and Polish. The BVA is currently being exposed to Switzerland, Denmark, Finland and Germany.

The proliferation into other European countries is through the Dutch and European professional engineering groups (in construction) who have observed that their expertise is not being utilized by owners. The Dutch Rijkswaterstaat organization is also exposing the BVA to other infrastructure organizations of other European countries. Also, other organizations exposed to the BVA in the Netherlands, are moving it to other European countries where they do business.

Future Scenario: Where Do We Want to Be in Ten Years?

In 10 years, the W117 BVA technology will be known and practiced in 10 major construction industries worldwide, next to the United States and the Netherlands. The technology has the potential to change national procurement models, project management models and risk management models. The Information Measurement Theory or the language of metrics also has the capability to change the traditional leadership models.

In these countries, the risk management model will change from the traditional model, which transfers risk by legal contracts, to a risk mitigation model, which identifies risk as what an expert contractor cannot control. The BVA will also mitigate risk by creating transparency, simplicity and utilizing performance metrics.

The successful research model of the future will be a mixed-methods model based on deductive logic and utilizing case studies. The research model will create change by showing dominant improvement in lowering project costs, increase profit margins and projects that are delivered on time and on budget. The approach is not technical in nature, making the W117 technology able to be applied to all industries.

Stakeholder's Vision of the Future

The stakeholders of the W117 technology are the stakeholders in the entire supply chain. Their vision is simple: lower project costs, higher project value, higher performance and higher profits. The success of W117 is that the BVA technology being developed is simple, easy to understand at a very high leadership level, but never the less, counterintuitive. The major requirements of the research effort is to document the technology in a way that fits the culture of the country. The results of the technology are so dominant, that the newer countries are adopting the approach with very few modifications. Education and training are the most critical challenges.

The following points summarize W117's development strategy and research contribution and development:

1. Development Strategy: What is needed in terms of knowledge, information, tools, concepts and applications to enable the respective systems, processes and technologies to support the BVA?

   The basic technology of the BVA performance information is already developed. There are two major stages of research development in every country. The first stage is the identification of expert "information workers" who understand the change of paradigm. The second stage of development is the running of academic/industry research tests. In each stage the following tasks have to be completed. First the communication of the technology, then the education of stakeholders, the acceptance of the change of paradigm and the running of the industry tests. The technology shall be modified slightly to accommodate the culture and understanding of the stakeholders.

   Before either stage can be successfully completed, tasks such as the translation of the English text into the local language and education sessions must be completed. The BVA has already been translated into Dutch, Norwegian, Polish and Arabic languages.

2. Research Contribution: How can research contribute to such development strategy? What are the requirements for research to make that contribution?

   W117 is unique in that it is led by the creator of the BVA and has the most expert BVA experts in the world. The W117 research and journal publication is the mechanism in proliferating the information technology. As more and more countries test the new approach, the documentation and database of results will optimize the future implementations, the information based technology, and increase the capability of the information based technology to be more robust and the identification of any cultural constraints. Never before in construction management research has a new paradigm utilized simplicity, performance metrics, transparency and the utilization of expertise to dominantly improve quality, reduce project cost and improve expert contractor profit margins. As discussed earlier, because the majority of academic researchers are involved in traditional research, a major contribution of W117 will be the changing of the research paradigm from the analysis of survey results to academic research/industry tests. The research publications will impact the change of paradigm in the areas of construction management, risk management and project management.

3. Research Agenda: What is the agenda for research worldwide?

   The research agenda of W117 includes simplification of the logic (IMT), translating the IMT into different languages, running tests in different cultures and environments, and implementing the logic to improve construction performance.

The W117 journal is being used to get the developments, results and new concepts to the industry stakeholders and researchers as quickly as possible. The journal will maximize the importance of peer review by academic and industry experts, and maximize the importance of the academic/industry test results. W117 research agenda is to proliferate the technology in as many countries and cultures as possible. W117 is always looking for innovative implementations of the BVA.

The research agenda includes the following innovations:

a. The W117 journal publications must receive wider dissemination in the academic world through the use of another internet system.
b. Changing the paradigm of the importance of academic research/industry testing instead of literature search and the analysis of survey results.
c. Moving all research results under the W117 umbrella and not a specific university.
d. Creating a full time W117 core team that will be more efficient in coordinating all W117 activities. Professor Kashiwagi will be responsible for organizing this team that will be responsible for the database of documentation, journal, secondary internet dissemination system and continued worldwide presentations.

Development Strategy

The CIB W117 development strategy is quite ambitious. The development will take place in three dimensions:

1. Knowledge.
2. Tools and applications.
3. Geographically.

These dimensions are set out in Figure 3.

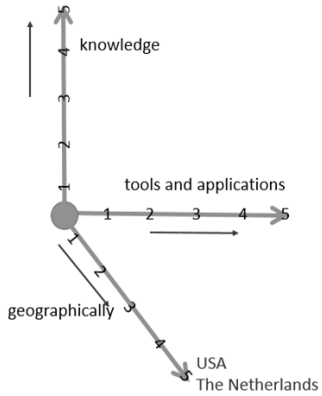

Figure 3: Dimensions of the W117 development strategy.

The knowledge on Value Management in Construction Performance Measurement is constantly being developed. Practitioners are constantly using the technology of the language of metrics and performance metrics. Practitioners are annually getting certified and running best value projects. The key to the BVA to all stakeholders is continuous improvement.

In the tools and application dimension, we use the technology that is a part of the "Information Measurement Theory" (IMT) which is the foundation for the Best Value Approach (BVA). As more and more areas of services are starting to use BVA, additional tools and applications will automatically develop.

The current BVA certification system shows that stakeholder participants have room for growth. Research can track the participant's performance metrics and improve a participant's chance for greater understanding.

The geographical dimension will develop through 'natural growth'. Great progress has been made in the USA, Canada and The Netherlands. W117 can now assist the movement into other countries. In Europe BVA has been introduced in Poland and Norway (Dutch book translated), and presentations have been given in Sweden, Finland, Denmark, Germany, Switzerland, Czech Republic, Hungary and the UK. A major effort is now happening in Saudi Arabia.

The aim of the geographical development is to find a platform that is willing to pick up BVA in the industry from both academia and practice (consulting, purchasing associations, association of engineers) to create a national body that can bring BVA further. This includes the basic materials in the mother language of that countries, licensed from ASU.

All the advancements will be published in the CIB/PBSRG journal.

Research Contribution

In the previous section we illustrated our development strategy. CIB W117 research is clearly contributing to that, mostly on the knowledge, tool and applications dimensions. The developed knowledge will also constantly be tested in practice.

Below we make some short remarks on the research contributions.

1. Opposite to government funded research (l'art pour l'art), resulting in reports and propositions, we propose to actively research practice in order to come up with solutions for the construction industry. Practical, applied research, resulting in applicable tools. One of the cornerstones of that research is construction practice itself, wanting the solutions and improvements to their ineffectiveness and inefficiency.
2. This means that we will use common academic research instruments like literature search, survey of industry perceptions, and case studies. Next to that we use every method that is needed to come up with practical knowledge and tools.

Obviously, we will report on these in publications, which are a means of communication, not a goal in itself.
3. Through our academic research community in construction we want to make things simple.
4. We will use systems like the deductive logic approach with natural laws of reality such as gravity and combustion that have no exceptions.
5. Successful knowledge and tools will continuously be tested in order to prove over and over their value for the construction industry. It is not the knowledge and tools themselves that have to proof their value, it is the acceptance by the construction industry's practitioners that we are aiming for.
6. We will use a peer review system for our journal based on these practitioners.

The core technology of the W117 is the Best Value Approach (BVA) and Information Measurement Theory (IMT). It is dependent upon metrics and the language of metrics in different processes to improve efficiency and effectiveness of the construction industry. These areas include: project management, risk management, procurement processes, communication between stakeholders and in the research that identifies the success or failure of hypothesis. The Stakeholders include, the entire supply chain of the delivery of construction services: designers, owners and all their representatives, regulatory groups, project managers, procurement personnel, lawyers, general contractors, subcontractors and material suppliers.

KSM, JSS and TU-Delft use their own funds and the available time of construction practitioners to do research. The W117 journal documentation of academic research/industry tests, and the number of new industry/country implementations will drive the research validity.

This different approach, new paradigm of industry testing and immediate results was recognized by CIB secretariat Wim Bakens in 2007, and led to the CIB general board approving a TG61 task group. The TG61 final report validated PBSRG and TU-Delft hypothesis, and led to the general board approving a new working commission W117.

Research Agenda

This section concludes with the agenda for W117 research in the construction industry worldwide. As previously stated in the Work Program, this includes:

1. Creating a CIB preferred journal to document the use of performance information in the construction industry and to publish research results for the practitioners in the construction industry, in order to improve effectiveness and efficiency.
2. Hold an annual CIB W117 meeting, to present and discuss the latest results of research in the use of performance information in the construction industry.
3. Do CIB W117 webinars to proliferate the exposure of the use of performance information in the construction industry.
4. Attend and participate in different international conferences to stimulate expert discussion on the use of performance metrics in the construction industry.

5. Conduct research on the use of performance information in the construction industry to develop state of the art practices in the construction industry. The agenda is set by practitioners that are willing to participate in the research.
6. Partner with different research groups to proliferate research on the use of performance information.
7. Expose different countries to the use of performance information in the delivery of construction.
8. Hold W117 meetings to assist different countries in implementing performance information in the delivering of construction services.
9. Hold meetings to help bridge the gap between academic research and industry practices.
10. Generate research funding (from practice) to do research in the use of performance metrics in the construction industry.
11. Create partnerships with active research and the CIB to self-fund CIB W117 activities and research, to be self-sustainable without CIB funding.
12. Have PhD's start their work at both PBSRG, TU-Delft and other W117 research-based universities. Have MSC students do their graduation projects on the use of BVA in the construction industry.

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A New Approach to Impacting the Construction Industry

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Construction industry performance (schedule, budget, and customer satisfaction) has not improved over the last 20 years. This investigation proposes that academic/industry research using actual project data may have more impact on improving industry performance than traditional survey-based research. The authors utilize the CIB and CIB W117 platforms to proliferate the concept of academic/industry test results to increase the impact on the construction industry. The authors propose to use the existing journal and then share the journal papers on an online platform (ResearchGate.net) ensuring a faster proliferation of the key academic/industry test results into the academic research community. The mechanism of the academic/industry test results will have more of an impact on industry practices than the traditional publication systems, which concentrate on literature reviews and surveys to collect industry opinions and analyze the information to change industry practices. The proliferation of industry research results will create transparency in the construction industry and the academic research community.

Keywords: Academic research, Industry testing, Performance.

Introduction

For the last 20 years, the construction industry has not been successful in their attempts to improve their performance (Egan, 1998; Lee, et al., 1999, Horman, M. & Kenley, R. 2005; Egbu, 2008). Research has shown that few academic research units conduct industry tests following the scientific method (Kashiwagi, et al., 2008; Strategic Direction, 2005). In 1994, Sir Michael Latham conducted a study which exposed construction non-performance in the United Kingdom (Latham, 1994). The results of this study caused members of construction academia and the construction industry to attempt to integrate both components (Kashiwagi, et al. 2008).

Despite their attempts, academic researchers in the construction industry were unable to increase the performance of the industry. In 1997, the United Kingdom commissioned John Egan to develop a task force and perform a study on the current (3 years difference) performance of the industry. Egan's study also identified a lack of leadership in the integration of academic research and industry practices as a cause for continual low performance (Egan, 1998).

Although Sir Latham and Egan sought to create a change in the way construction industry academics remain apart from the construction industry and actual tests, the construction industry has seen minimal improvements (Chikuni & Hendrik, 2012; Oyele et al., 2012; Gregory et al., 2005; Bernstein, 2003).

Studies have been conducted in the United States yielding the following results:

- Over 90% of projects in transportation construction are over budget (Lepatner, 2007).
- Close to 50% of time is used inefficiently on job sites (Lepatner, 2007).

- Projects are over budget an average of 27% (Kashiwagi, 2013).
- 25% to 50% of resources are wasted on a project (Lepatner, 2007).
- Management inefficiency costs owners between $15.6B and $36B per year.
- $4 to 12B is spent trying to resolve disputes and claims (Lepatner, 2007; PWC, 2009).
- Major infrastructure projects typically overrun costs by 50%, some ranged from 255% to as high as 36,000% (Lepatner, 2007).
- In 2015, a study by the Construction Industry Institute (CII) identified only 2.5% of construction projects worldwide are successful (on time, on budget, with high customer satisfaction) (CII, 2015).

International construction management research has existed since the mid -1980s, but in that time, construction management research has not been effective in increasing construction performance. Possible causes may be that the industry and academia do not integrate with each other (operate in silos). The academic research community has not been successful in identifying the problem or the industry is directing the academic research direction and the industry does not know what the solution is.

Problem

Construction management research has continued to advance over the last several decades but performance in the industry is still in decline. Figure 1 shows the increment of publications made in the construction management area since 1938.

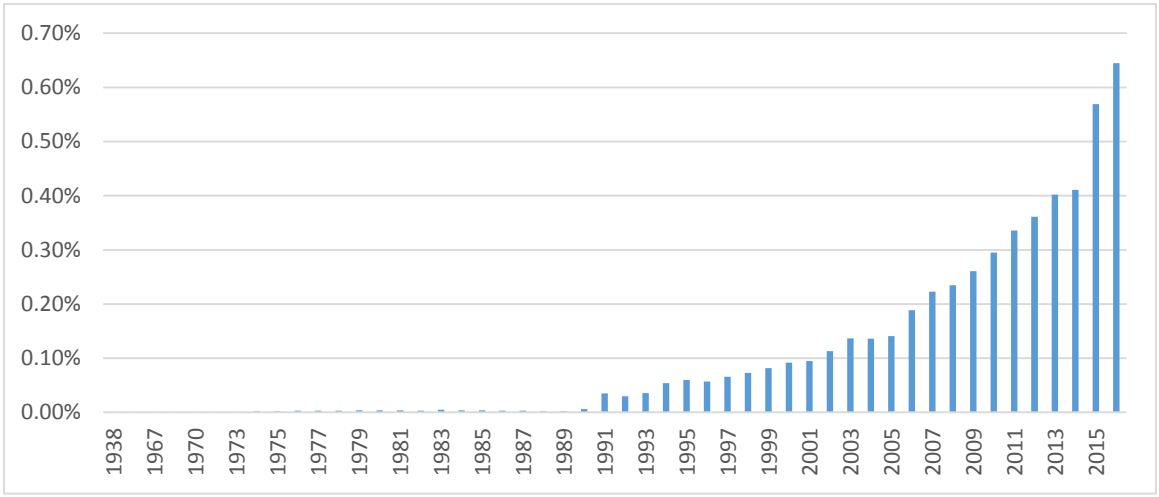

Figure 1: Percentage of publications related to Construction Management since 1938 (21,311 publications analyzed in total).

Despite the increased interest in academic publications in the construction management field, the performance of the industry has not improved. The problem may be that efforts made through academic research are not yielding measurable improvements to industry performance.

Traditional Research Methods

In 2011, Graham et al suggested that the majority of research being conducted in the construction field is disconnected from the actual needs of the industry. They concluded by stating that "a review of literature show that, historically, research has not played a major role in the advancement of the construction industry" (Graham, et al., 2011). In the United States, the National Academy of Sciences has stated that the research agenda of the nation as a whole does not cover the entire industry and is unable to identify the research areas that would improve the performance of the construction industry (NAS, 2009).

In 2006, a study by Task Group 61 (TG61) commissioned by the International Council for Research and Innovation in Building and Construction (CIB) sought to identify academic research units that improved the delivery of construction services. TG61 tried to identify research supported by project-based performance metrics, as opposed to literature research and survey data. TG61 conducted a literature search spanning 15 million articles, 4,500 of which were directly reviewed. Of these articles, only 16 identified 3 methods which claimed to increase performance through research testing. These were:

1. Performance Assessment Scoring System (PASS).
2. City of Fort Worth Equipment Services Department (ESD – FT).
3. Performance Information Procurement System / Performance Information Risk Management System (PIPS/PIRMS).

The authors found that PASS and ESD – FT were not supported by project-based performance metrics to validate their claims. These studies are strictly qualitative and do not provide evidence-based methodologies that can be replicated or tested (Kashiwagi, et al., 2009; PBSRG, 2014). While PASS and ESD-FT claim the ability to improve project performance, both studies are not supported by project-based research, so neither of them fit within the parameters of TG61.

A Non-Traditional Approach

The third research unit that TG61 evaluated is PIPS/PIRMS used by the Performance Based Studies Research Group (PBSRG). PIPS/PIRMS is the only research methodology examined in the TG61 study that is supported by project-based performance metrics (Kashiwagi, 2014). Therefore, CIB TG61 concluded that PBSRG is the only academic unit capable of improving the performance of the construction industry. Founded in 1993, PBSRG is backed by the following historic research performance metrics (Rivera, 2013; Kashiwagi, 2014; PBSRG, 2014):

- 1,900+ projects and services delivered.
- $6.8B of projects and services delivered.
- 98% customer satisfaction.
- $17.3M in research funding generated.
- Decreased the cost of services by 31% (average).
- Decreased efforts by the client by up to 79%.
- Identified the highest performing expert at lowest cost 57% of the time.

PBSRG claims that their success is attributed to their ability to recognize and address industry issues directly because researchers focus on validating academic publications through project-based testing. The TG61 study suggests that this methodology is unlike anything else currently being done in academia, making it a very "non-traditional" approach. Nevertheless, this finding led CIB to elevate TG61 to a working commission: W117 "Performance Measurement in Construction," and partner with PBSRG to proliferate academic/industry results and motivate other researchers to do the same (Kashiwagi, et al., 2009; PBSRG, 2014).

Resistance to New Approaches

Despite the effectiveness of the research efforts at PBSRG, other academic units refused to adopt this non-traditional model. Before their partnership with CIB, in 2005, PBSRG presented its methodology to the National Science Foundation (NSF), which is an organization tasked with providing grants to higher education institutions with innovative research and proven past performance. The NSF denied PBSRG funding and advised them not to resubmit because their methods are "poorly constructed," and "not relevant." According to the PBSRG director, this was a common viewpoint at the time. Many high-impact journals were not interested in research done at PBSRG because it was too unique and did not fit within traditional academic parameters

As a result of the common resistance, the research at PBSRG was not adequately distributed to other researchers for effective peer evaluation and examination. In 2014, for example, Xu Jun, a graduate student from China had spent over 6 years conducting research on the needs of the construction industry in China. Jun proposed "guanxi" as one of the main reasons foreign methods and systems needed to be modified before being implemented (Jun, 2014). Guanxi being a form of business relationship deeply rooted in the Asian culture. Dr. Dean Kashiwagi, one of the examiners of Xu Jun's presentation identified similarities between "guanxi" and "bakshish," a form of business relationship found in the Kingdom of Saudi Arabia. Dr. Kashiwagi and Xu Jun made the following observations:

- Guanxi and Bakshish are based on business relationships instead of performance.
- Relationships had been identified as inefficient and one of the causes of low-performance in PIPS/PIRMS research. (Kashiwagi, 2014)
- PIPS/PIRMS directly addressed business relationships in over 6 countries for the previous 20 years (Kashiwagi, 2014).
- Xu Jun was not aware of Bakshish (Guanxi was not unique) or of PIPS/PIRMS results.

Uniting Academia and the Industry

While the efforts at PBSRG have not been widely accepted by the greater academic community, several key stakeholders have recognized the effectiveness of their research. Harvard University funded 6 construction tests that utilized PIPS/PIRMS. All 6 of these projects were completed with following results:

- Delivered at lower cost.
- Minimal administrative costs/time (compared to traditional project delivery methods).
- Higher performance rating (compared to traditional).

PBSRG and Harvard University were awarded the CoreNet Global Innovation of the Year Award (Sullivan, 2007) for the results yielded by the tests. The CoreNet Global Innovation of the Year Award is an industry recognition given to high-performing groups for achieving high-performance in otherwise low-performing areas.

The research done by TG61 and the story of PBSRG suggest that the larger academic community might be disconnected to the immediate needs of the industry. Most construction management publications are not based on project-based performance metrics. Research done at PBSRG has been often disregarded as irrelevant. The underlying problem is that academia and the industry are not working in a cohesive and efficient manner that can lead to long-term improvement of overall project performance. The authors propose that this disconnection is a result of the following:

1. Modern research is based on survey data, not project performance information.
2. Research is commonly published one to two years after the data is collected, which delays industry implementation and further project-based testing.

Proposal

This research proposes that in order to closer unite academic research and the needs of the construction industry, non-traditional methods of research and publications should be further developed. The authors suggest that this objective can be achieved, in part, by creating a journal that is first, supported by performance-based research, and second, easily accessible to both researchers and industry professionals. This journal can bypass traditional publication systems that are often delayed by journal requirements and lengthy peer-review processes. The implementation of this new journal type is as follows:

1. Create a journal that concentrates on academic research/industry test results to improve industry performance.
2. Identify a method to increase the transparency in research work that identifies “accurate” and “inaccurate” concepts by using research tests with metrics (instead of industry opinions).
3. Identify a way to document and proliferate the test information (database, journal publication and secondary publication system).
4. Identify the impact of the performance information by documenting the movement of the paradigm into more cultures, countries and other industries.

Methodology

The proposal will be validated (or refuted) through the following steps:

1. Request CIB create a platform (journal and website) where performance-based research can be shared. The journal publication of academic/industry test results will minimize inaccurate ideas in academic research.

2. Ensure publication of test results in the journal publication at least 2 times from 2015 to 2017.
3. Create and identify academic or industry experts to serve as peer reviewers (list to be created prior to the first publication in 2015).
4. Create a database of test results to share with experts/researchers. This will serve as a secondary publication system that will exponentially expose the academic/industry test information.
5. Integrate the performance information of research tests into real-world projects to increase the number of research/industry tests.

In order to test the effectiveness of this research method, the authors will create a two-year (2015 – 2017) evaluation period. In that timeframe the effectiveness of the new publication will be measured by tracking the following performance metrics:

- Journal publications 2 times per year, or at least improved from the baseline year (2014).
- Expert peer reviewers available (at least 2 per publication being considered).
- Number of reads of work shared on secondary publication system.
- Amount of citations gained through the sharing of test results on secondary publication system.

Results

All research test results listed here-after are directly correlated with a step listed in the methodology, performed from 2015 to the start of 2017, and utilizing 2014 as the baseline for previous performance unless otherwise specified.

Transparency through a Journal Publication

The academic unit conducting PIPS/PIRMS research identified publishing papers in non-CIB W117 journals more difficult and time consuming, shifting their primary focus to W117 as the sole tool to proliferate research tests. In 2014, only 1 issue had been published with a total of 6 research papers in it. Since 2012, the rate of issues and total number of papers published had been steadily declining since its peak in 2012. A new publishing system was implemented at the end of 2015, capable of reviewing, editing and publishing of 11 papers in 2 weeks (W117, 2016). The following years, including the expected publications in 2017 can be found on Table 1.

Table 1

Performance Data Information with 2014 as Baseline

Year	Issues	Papers
2014	1	6
2015	1	11
2016	2	15
2017	2	14

On Table 1, year 2014 is used a baseline, since it is the year prior to the start of the research. One of the goals of the research was to stabilize the number of issues published per year (at least 2). Due to the late approval of the research in 2015, only 1 issue could be published that year. However, the issue contained almost twice as many papers as the baseline year, and it is recorded as having been published, from the time of deadline to submit, in 2 weeks.

A review of every article published by W117 in the Journal for the Advancement of Performance Information and Value (JAPIV) showed over 80% as being case studies or data directly relating to academic/industry testing, causing the JAPIV to now be a recommended journal from the CIB (W117, 2016). Additionally, CIB recognized W117 as the highest-performing working commission at their Annual World conference, citing the innovative approach to proliferating academic/industry information as one of the main sources for their success (CIB, 2016).

Wim Bakens, director of CIB, tasked W117 directors with creating a roadmap other working commissions could replicate to increase the performance and impact of their research. Furthermore, he assigned Dr. Kashiwagi (director of W117) to present at the World Building Congress as well as provide seminars to other coordinators of working commissions.

Experts as Reviewers

The new publishing systems utilizes industry experts and researchers who have previously been exposed to the impact academic testing in the industry can have on improving performance on projects. As of May 2017, 45 CIB members serve as reviewers for the W117 journal. 31% are high-performing industry experts in the field; 69% are researchers from like-minded universities. Some of the member organizations include:

- Arizona State University
- Central Building Research Institute, India
- City of Rochester Minnesota, USA
- Construction Research Institute of Malaysia
- Danish Building Research Institute, Denmark
- Ministry of Municipal Affairs, Saudi Arabia
- ON Semiconductor, worldwide
- RMIT University, Australia
- Scenter, Europe
- The Barlett Faculty of the Build Environment, United Kingdom
- Universidade Federal do Rio de Janeiro, Brazil
- University of Alberta, Canada
- University of Kansas, USA
- University of South Africa
- University of Zagreb, Croatia
- VTT Technical Research Centre of Finland
- Western Illinois University, USA

Utilizing experts who are aware of the importance of industry testing can quickly identify accurate and inaccurate proposals, thus optimizing the review process.

Secondary Publication System

At the start of 2016, the main researcher identified ResearchGate.net as a platform where research/industry testing results could be shared in addition to the W117 website. Prior to this, W117 only possessed their website to disseminate their research results, possessed no noticeable transfer of information to researchers not directly linked to CIB except by direct contact of primary researchers in any given publication.

ResearchGate.net is an online platform designed to ease the sharing of research work being performed around the world. From the start of 2017, ResearchGate has 12M+ researchers registered (about 60% of potential users) boasts of higher activity usage than Academia.edu (other research sharing platform), and easier sharing ability than Google Scholar (an online "platform" composed of databases). ResearchGate has been called "a mash-up of Facebook, Twitter and LinkedIn," by the New York Times (Scott, 2017). The work of editors from W117 and other PIPS/PIRMS researchers was added to the site at the start of 2016.

The result of adding these documents are as follows (from January 2016 to May 2017):

- 76 full-text articles shared.
- 4,985 reads.
- 86 followers.
- 944 unique researchers reached.
- 252 additional citations (mentions of W117 research work in non-W117 publications).

More importantly, the increase in exposure as well as more dominant case studies being reported more recently has led to an exponential increase in work being cited, as seen in Figure 2.

Figure 2: Citations count of paper, by year.

Integrating Performance Information in Proliferation Systems to Increase Test Counts

As of May 2017, 2 years into implementation of the new publishing system, W117 and JAPIV has experienced the following results:

- The procurement and major government organizations in the Netherlands has identified the BVA as the mainstream and most recommend approach to delivering construction and other services.
- Norway has awarded the first project [350M Euros infrastructure improvement] and has 10 projects that are ongoing. W117 will be documenting all tests.
- W117 experts are educating and assisting Polish professionals to run their first tests. State of Utah will reopen academia/industry testing after 16 years.
- JSS engineering university [rated in the top 50 engineering university] in Mysore, India is importing the entire W117 research/education program and plans to implement a BVA Master's degree to support academic /industry research.
- Education and testing in China and Vietnam.
- Saudi Arabia is implementing the BVA and information technology to classify all contractors and continuously track their project performance.
- Education programs for high schools are flourishing in the Phoenix metropolitan area and online.
- W117 approach has been requested by CIB board as a template for other working commissions who are having difficulty in sustaining and impacting industry.

Conclusion

The amount of research data has exponentially increased over the years in the construction management area. Despite this, the performance of the construction industry has not been impacted for the last 30 years. In 2006, the CIB tasked TG61 with identifying systems which utilized performance-based research tests to improve the performance of the construction industry. Literary research in addition to performance data gathered by TG61 and now W117 shows that academic/industry research testing of "real" cases has more impact on the performance of the construction industry than traditional academic research, which utilizes survey results as the main source of information. CIB, W117 and ResearchGate.net are proving to be the most efficient ways to disseminate information. These 3 platforms ensure a faster flow of information of test results, making it more effective than traditional publication systems in impacting or changing industry practices. The integration of research/industry tests and results with journal publications and a secondary online platform is what now has an impact on the construction industry and its industry practices.

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Professionals' Impressions Regarding the Saudi Arabian Procurement and Contracts System

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Saudi Arabia (SA) has the largest construction market in the Middle East. However, the use of the traditional procurement system in SA has been identified as one of the causes for poor performance in the delivery of construction. The system has been identified as a major risk to the SA government due to consistent increased costs and delays of up to 70% on projects. A survey was conducted with 1396 participants including engineers, buyers, contractors, consultants, academics, and architects. The purpose of the survey was to identify the validity of the recent claims that the procurement system in SA is broken. The participants work in both the private and government sectors. The survey results showed that the procurement system is a major risk to projects, affects construction projects negatively, and is in need of improvement.

Keywords: Saudi Arabia, Construction, Performance, Risk, Procurement.

Introduction

The largest market in the construction industry in the Middle East is Saudi Arabia. Also, it is expected that this growth will continue until 2015 (World Construction, 2012). Al Turkey (2011) conducted a survey through 300 project managers from several sectors about the important issues that face the construction industry in Saudi Arabia. This survey found 80% of projects suffer from increased costs, and 97% of projects exceeded the time limit of projects completion. Also, Al-Ghafly (1995) conducted a survey to determine the degree of delay in construction projects among owners, contractors and consultants. The consultants believe 84% of the projects suffer from delays, but contractors only believe that 37% of the projects have delays. Moreover, Zain Al- Abedien (1983) and Al-Sultan (1987) found that around 70% of projects suffered from delays in Saudi Arabia. The delays were inescapable because the contractors were selected on the basis of the lowest price (Assaf and Al-Hejji, 2006). Also, Assaf and Al-Hejji found the major cause of delay in construction projects is change orders (2006). Other reasons such as incorrect estimation, lack of experience, inadequate decisions in companies' policy are strong causes of issues of construction projects in Saudi Arabia (Al-Barak ,1993). A. Alofi (2016) proposed a solution to develop Saudi Arabia's procurement system by analyzing the current procurement system and conducting a survey. The survey was sent to professionals who work in the public sector and have an interest in procurement and contract system in Saudi Arabia. Depending on the survey, a new phase has been added called clarification into current procurement system in Saudi Arabia. By adding this new phase to the system, the outcomes of the system will be improved in the majority of projects in the Kingdom of Saudi Arabia (A. Alofi, 2016).

Problem

The Saudi Arabian procurement system is the major cause of the issues on construction projects in Saudi Arabia. Moreover, the system leads to many delays and negative impacts in projects. The negative outcome comes from the way of contractors' selection who have been selected based on lowest price (Albogamy et al., 2012). In addition, the majority of contractors who have been selected are not qualified (Assaf and Al-Hejji, 2006). Alyaum newspaper (2013) interviewed Nasser Al-Hajri, who works in the eastern region at Chamber of Commerce and is interested with the procurement system in Saudi Arabia, says that the use of the Saudi Procurement System (SPS) causes problems and delays in construction projects. Also, the system has not been optimized in a long time.

Proposal

The research proposes that by conducting a survey upon 1396 participants about the major issues arising from the use of the traditional SPS, which selects contractors on the lowest price. The main objectives of the research are as follows:

- To identify the perceptions of a big number of interested professionals private and public sectors around the SPS.
- To prove that the system is the main reason for the delays in the most of construction projects in Saudi Arabia.
- To identify if the professionals agree with any future improvement on the system.
- To propose solutions for the future development of the SPS.

Methodology

In order to conduct the research, the authors did the following:

1. Verify that the most important issue of the construction industry is the SPS through lecture reviews
2. Propose hypothesis that the procurement system is broken and needs to be developed
3. Conduct a survey about the perceptions of the SPS by using a sample of participants who work in the construction industry with an interest in the procurement system such as contractors, owners, consultants, engineers, architects, etc.
4. Conduct and analyze the data and compare perceptions.

Survey Design

The survey was carefully designed in order to get the participant's perceptions over the system of contractors' selection, the impact of the procurement system on the projects, and the impact of contractors who have been selected by the SA procurement system on projects. Also, the survey has been collected in order to identify the perceptions and satisfaction of participants who work in the construction industry in both the private and governmental sectors with the current Saudi Arabian procurement system.

The questions that have been asked are as follows:

1. Do you think that the traditional SPS chooses non-expert contractors?
2. Do you think that the traditional SPS leads to project delays and increased costs?
3. The huge Difference between market prices and the lowest proposal price leads to losses in time and money.
4. Do you think that contractors who have very low and high prices affect the project negatively?
5. Do you think contractor selection depending on how low-bid has a negative impact on construction projects?
6. Do you feel there needs to be a change in the traditional SPS?
7. What is your satisfaction with the traditional SPS? (1-10, 10 being the best).

The Professionals were able to answer the questions by using two different scales:

1. Strongly Agree; Agree; Don't know; Disagree; Strongly Disagree.
2. Yes; No; I am not sure.

The survey has been sent to the participants who have been licensed by the government engineering professional group in SA through using the organization access. Moreover, the data was collected through 1396 participants out of 12683 participants who are interested with the procurement system and contracts in Saudi Arabia. The total number of participants who work in private sectors is 1151 participants, which included 710 engineers, 223 consultants, 88 contractors, 26 owners and 104 architects. In addition, the information collection in this paper considers 245 participants who work in governmental sectors including 157 engineers, 33 consultants, 9 owners, 5 vendors, 28 architects and 13 academics. All the participants of the private and government sectors have experience between a year and more than 25 years in different types of construction areas such as residential and commercial buildings, healthcare buildings, industrial building and heavy civil construction.

Results

The survey questions were designed carefully to identify the real perceptions of the participants regarding the Saudi Arabian procurement system. Some participants did not answer some survey questions, either for lack of their knowledge or for other specific reasons. Therefore, it has been considered only in those who have enough knowledge of the survey questions. Around fifty-four percent (53.51%) of the participants who work in private sectors think that the procurement system in Saudi Arabia chooses non expert contractors. Alofi (2015) identified that around eighty-one percent (80.61%) of them who work in government sectors think that the contractors who has been chosen in Saudi Arabia are not experts.

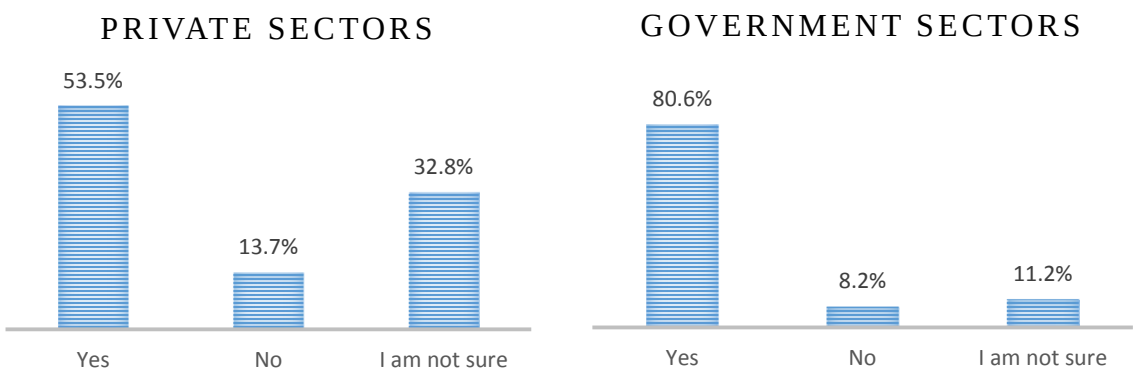

Figure 1: The procurement system chooses non expert contractors

As seen in figure 2, approximately seventy-three percent (73.41%) of the private participants think that the traditional SPS leads to project delays and increased costs. Eighty-six percent (86.39%) of governmental participants agree with the question.

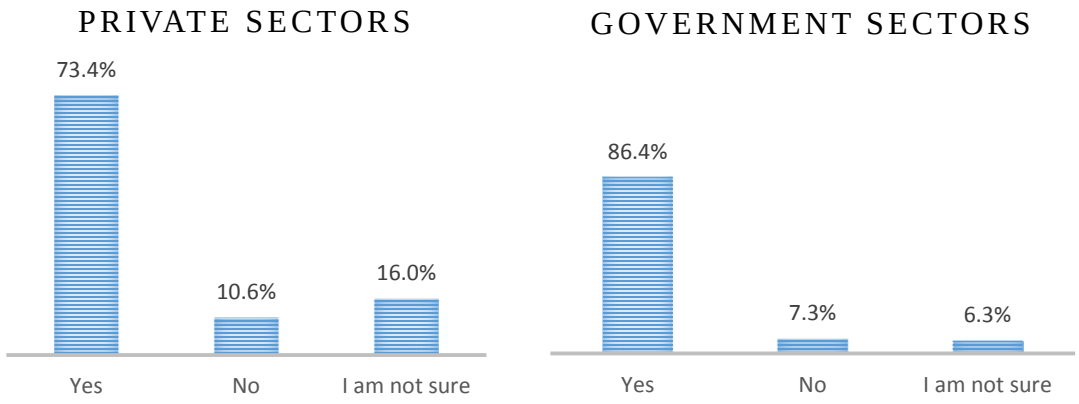

Figure 2: Traditional SPS leads to project delays and increased cost

Around seventy-two percent of the participants who work in private and government sectors agree that there is a large difference between market prices and the lowest proposal price (35% less than market prices) thus maximizing losses in time and money, while only around eight percent (8%) of them disagree with it as is shown in figure 3. In addition, from the governmental participants, there are approximately ninety-four percent (94.1%), and eighty-eight (88.5%) from private sectors who think that the contractors who have very low and high prices affect the project negatively in Saudi Arabia as is seen in figure 4.

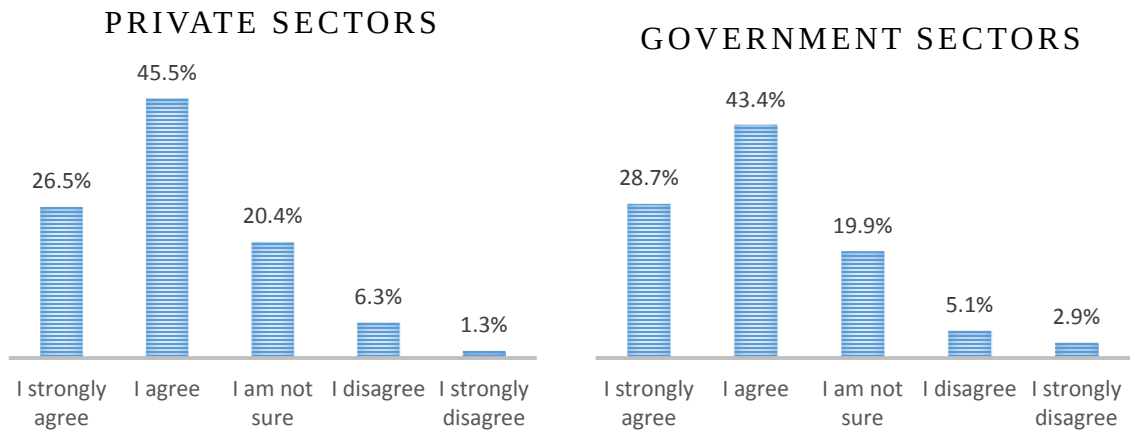

Figure 3: difference between market prices and the lowest proposal price leads losses in time and money.

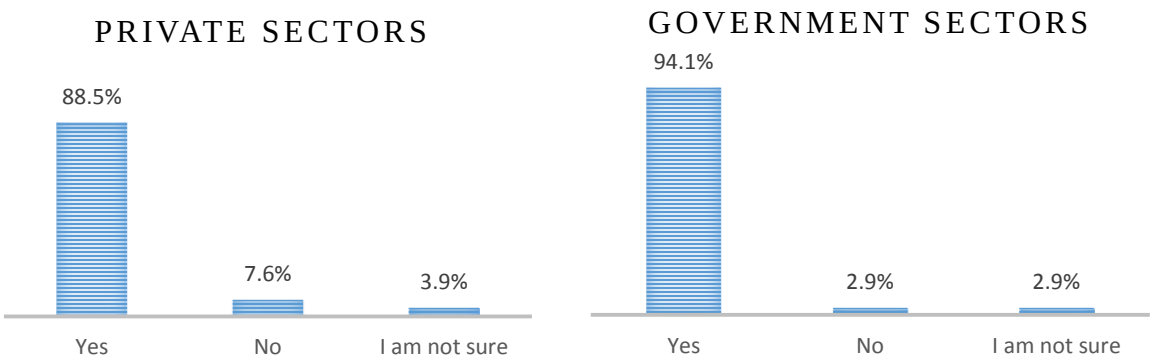

Figure 4: The contractors who have very low and high proposals, affect the project negatively in Saudi Arabia.

Figure 5 shows that around ninety-three percent (93.4%) of the participants who work in government sectors think that the contractors' selection depending on low bid has a negative impact on construction projects (Alofi, 2015). Ninety-six percent (96%) of them who work in private sectors think that the Saudi Arabia projects has negative impacts due to the method of selection of contractors.

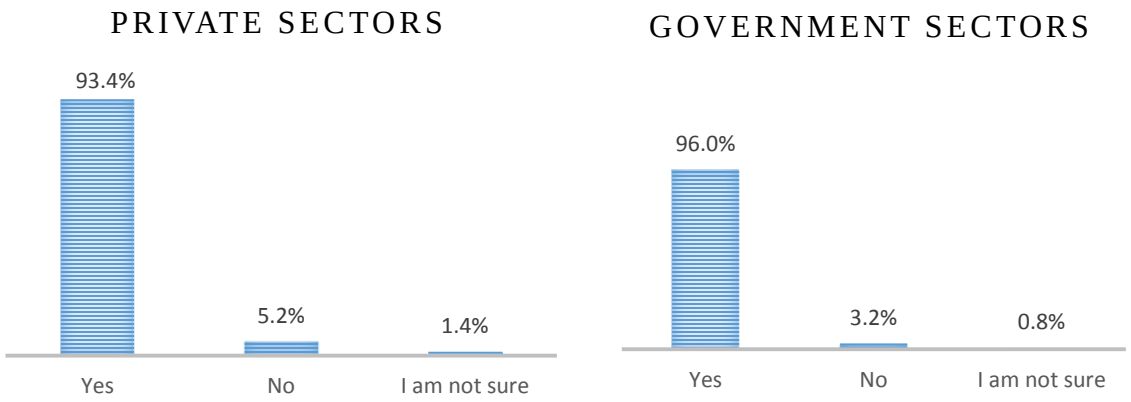

Figure 5: Contractors selection depending on low bid has a negative impact on construction projects.

Moreover, about ninety-six percent (96.2%) of participants of government sectors, and around eighty-eight percent (87.8%) of participants of private sectors feel that there needs to be a change in the traditional SPS as is seen in figure 6. The participants' satisfaction from private sectors with the traditional SPS is 5.03 out of 10, while the satisfaction of governmental participants is 4.21 out of 10.

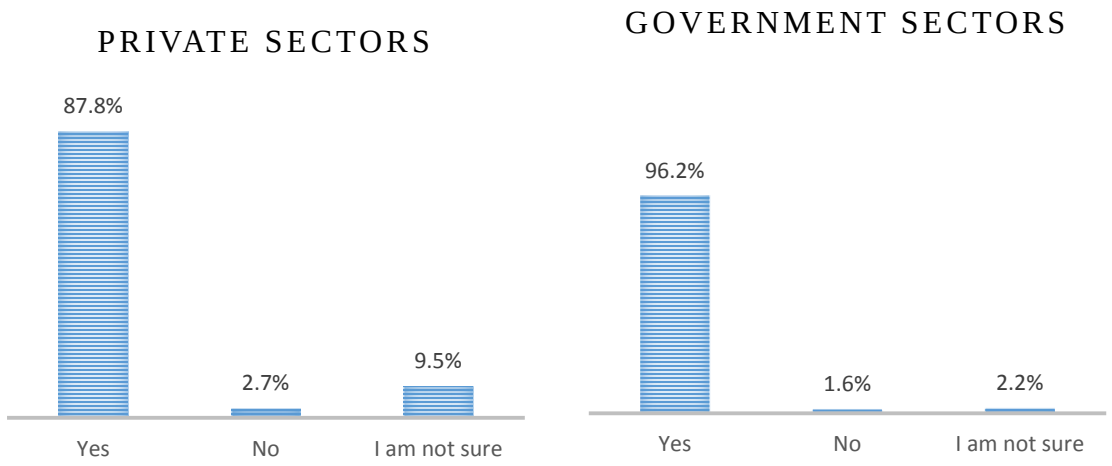

Figure 6: Participants feel that there needs to be a change in the traditional SPS.

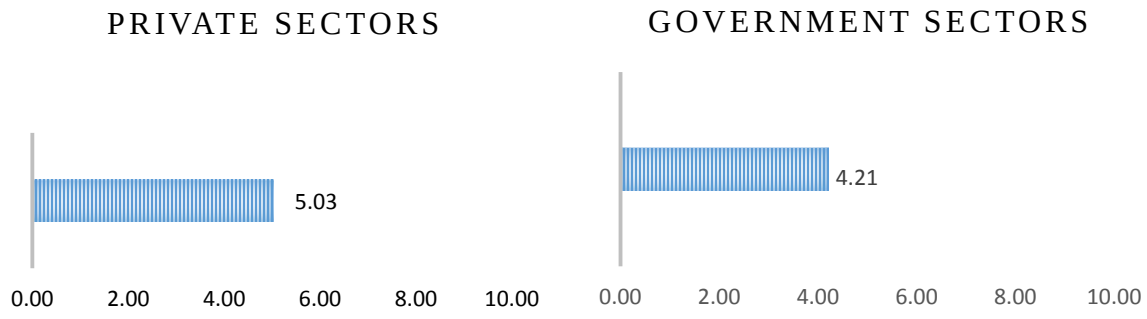

Figure 7: The participant's satisfaction with the traditional SPS, (1-10) 10 is the best.

Table 1 shows the percentage of agreement of the participants who work in the private sector about the following statements: the system chooses non-expert contractors and leads to delays, low-bid method negatively affects projects, very expensive and cheap proposal negatively affect projects, the participants feeling and satisfaction with current SA procurement system. The table shows the data depending on 25 years of experience or more with different types of projects such as residential buildings, commercial buildings, healthcare construction, industrial construction and heavy civil construction. Moreover, as shown, the ratios that have been obtained are convergent between the different types of projects. More than 80% of respondents agreed with the statements and about 60% of them agreed that the system selects unqualified contractors. A slight difference in the results of the participants who work in heavy civil construction, about 78% of them believe that the SA procurement system leads to delays at projects and around 76% of the them believe that the low-bid influences negatively on the projects. In addition, 56% of the participants in heavy civil construction believe that the system selects unqualified contractors.

Table 1

Perceptions of the participants from the private sector about the SPS, depending on the type of project.

Type of project	The system chooses non expert contractors	The system leads to project delays	lowest proposal definition has a negative impact	Low and high proposals has a negative effect	Low bid has a negative impact	System changing	Satisfaction
Residential buildings	60.5 %	83%	88.7%	94.3%	100%	96%	4.64 out of 10
Commercial buildings	61%	84.6%	83.7%	93%	100%	100%	4.74 out of 10
Healthcare construction	56%	82.9%	84.6%	92.3%	100%	100%	4.33 out of 10
Industrial construction	68%	87.2%	86.2%	93%	100%	95.5%	4.84 out of 10
Heavy civil construction	63%	78.8%	76%	100%	95%	94%	4.79 out of 10

In addition, as seen in table 2, the perceptions of the participants who work with government sectors are shown and have 25 years or more of experience. Almost all the participants agreed with all statements. 71.4% of participants who work at residential buildings and around 75% of them who work at commercial buildings agreed that lowest proposal definition has a negative impact on projects. In addition, about 80% of them who work at commercial buildings and about 75% of the participants who work in healthcare construction agreed that the SA procurement system selects unqualified contractors.

Table 2

The percentage of agreement of the participants from the governmental sectors about the SPS, depending on the type of project.

Type of project	The system chooses non expert contractors	The system leads to project delays	lowest proposal definition has a negative impact	Low and high proposals has a negative effect	Low bid has a negative impact	System changing	Satisfaction
Residential buildings	100%	100%	71.4%	100%	100%	100%	3.88 out of 10
Commercial buildings	80%	100%	75%	100%	100%	100%	4 out of 10
Healthcare construction	75%	100%	100%	100%	100%	100%	3.5 out of 10
Industrial construction	100%	100%	100%	100%	100%	100%	3 out of 10
Heavy civil construction	100%	100%	100%	100%	100%	100%	4.8 out of 10

Analysis

The survey results reflect the real problem emanating from the procurement system in Saudi Arabia, which was one of the main reasons for this paper. As is seen, the results are convergent between the perceptions of participants in the public and private sectors in Saudi Arabia. However, the results of the government sector reflected more positive and agree with the objectives of the research compared to those who are in the private sector. For instance, about 89.33% of participants who work in the public sector agree that the Saudi Arabian procurement system leads to projects delays, chooses non expert contractors, affects the projects negatively in very cheap and expensive proposals and feel that there must be a change in the SPS, compared with 75.8 % of participants in the private sectors, which is 13.53% less than public sectors.

On the other hand, only on one question (if contractor's selection depending on low bid has a negative impact on construction projects) is the result larger in the private sector by about 96% compared with the government sector, which gave a result around 93.4 %, with 2.6% difference between the two sectors. Moreover, there is no difference in the results between the sectors concerning the difference between market prices and the lowest proposal price, which leads to losses in time and money. Also, there are about 4.8 % from the government sector and 12.6% from the private sector who are not sure about some questions, for either lack of their experience or for other specific reasons.

Conclusion & Recommendation

Saudi Arabia suffers from several challenges and issues resulting from delays in the majority of construction projects. Many studies have identified that the main reason for project delays is the selection of contractors who have been selected by using the Saudi Arabia's procurement system. The contractors are selected only based on the lowest price, so the majority of the selected contractors are not eligible. A survey was conducted with 1396 participants from the private and public sectors on their perceptions and satisfactions about the procurement system in Saudi Arabia. The results showed that the procurement system is broken, has negative impacts on projects, and it is in need of development.

After obtaining the perceptions of the participants in the survey, the researchers recommend fast improvements and radical changes in the SPS to improve its outputs, all cheap and very expensive proposals should be excluded, add new phases to test contractors to make sure that contractors are qualified before signing contracts, contractors should be monitored during construction work in order to ensure delivery of the project on time on cost, and reduce the owners' control on contractors. The researchers recommend more research to develop the procurement system, due to its high value in the development of the construction industry in Saudi Arabia.

The questionnaire was collected among 1396 professionals who are interested with the SPS, and found that 73.41% of the private participants and 86.39% of governmental participants think that the traditional SPS leads to project delays and increased costs. Around seventy-two percent from the participants who work in private and government sectors agree that there is a large difference between market prices and the lowest proposal price, thus maximizing losses in time and money, however only around eight percent from them disagree with it. From the governmental participants, there are approximately ninety-four percent (94.1%), and eighty-eight (88.5%) from private sectors think that the contractors who have very low and high prices affect the project negatively in Saudi Arabia. Around ninety-three percent (93.4%) of the participants who work in private sectors and ninety-six percent of them who work in government sectors think that the contractors' selection depending on low bid has a negative impact on construction projects. About ninety-six percent (96.2%) of participants of government sectors, and around eighty-eight (87.8%) of participants of private sectors feel that there needs to be a change in the traditional SPS. The participants' satisfaction from private sectors with the traditional SPS is 5.03 out of 10, while the satisfaction of governmental participants is 4.21 out of 10.

The researchers have found that one of the most successful procurement systems in the world is the performance information procurement system (PIPS) with 98% of customers' satisfaction (PBSRG, 2014). It consists of four different phases to choose an expert contractor (Kashiwagi, 2014). The model has been tested about 1750 times during 20 years in around 31 states in the United States of America (PBSRG, 2016).

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A BVA Telephone Facilities Project: Lessons Learned

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The Municipality of Eemsmond has been searching for a way to improve their method of delivering Telephone facilities in order to improve program requirements. To achieve this goal, the Best Value Approach was identified as the optimal system. The Best Value Approach was successfully implemented in the contracting and execution phases of a Telephone Facilities project. An expert was found with a quality solution that delivered the project two months earlier than required and below the expected budget. The advantage of the Best Value Approach was that it identified the client satisfaction and outcome as the most important aspect of the project instead of focusing on the specific technical requirements and method used to accomplish it. This paper will review the results of the Telephone Facilities project and the lessons learned in regard to the Best Value philosophy and methodology.

Keywords: Best Value Approach, Information Technology, Netherlands, City government.

Introduction

Eemsmond (English: Ems Mouth) is a municipality located in the north-east of the province of Groningen, The Netherlands (Figure 1). A municipality is usually an urban administrative division having corporate status and powers of self-government or jurisdiction. Eemsmond, in geographical size, is one of the largest municipalities in the Netherlands. The municipality of Eemsmond has roughly 16,000 residents of which 185 are employed at the municipality. The municipality's mission and vision include:

1. Maintaining order while moving with the style, trends and character of the community.
2. Responding to new developments in society through interactive policy development that align with the local community.

Figure 1: Eemsmond area.

Best Value at Eemsmond

In 2015 the ICT department of Eemsmond was preparing a Request for Proposal (RFP) to procure new Telephone Facilities. Due to their experience in the past with traditional ICT and telephone contracts, which seemed to produce non-performing vendors, the municipality saw the need to find a different method to identify and select an expert vendor.

In 2015 the purchasing department of Eemsmond organized a presentation to introduce the ICT department's management and project managers to the Best Value Approach. The BVA provided an alternative way to procure and manage services by emphasizing the need to increase the utilization of expertise and minimize the buyer's use of management, direction and control (Kashiwagi, 2016; Kashiwagi, 2013; Rivera et al, 2016). After the presentation, a project manager of the ICT department decided to run a pilot project utilizing the Best Value Approach.

Telephone Facilities

In January 2016, the project manager proposed to use the Best Value Approach to run the Telephone Facilities project. The Telephone Facilities project consisted of the delivery of a fully integrated "in the cloud" communications platform, including delivery of hardware and software needed for communications (computers, wires and computer programs). The Vendor would be responsible for hosting the (new) facilities and the maintenance, which includes updates and upgrades during the contract.

The proposal to use the Best Value Approach was approved by the management of Eemsmond. One of the key benefits that interested the municipality was the claim that through the Best Value Approach an expert vendor could be identified without requiring the client to know exactly what they want (Kashiwagi, 2015; Sullivan, 2007; Kashiwagi, 2013). Due to the many different options and technical requirements of the project, it was one of the determining factors in deciding to apply the Best Value Approach to the Telephone Facilities project. The project team and the project manager were both pleasantly surprised by the Best Value Approach (BVA) which is based on the concepts of listening, understanding, aligning, accepting reality, and utilizing logic and common sense (Kashiwagi, 2016b). This approach was perceived as contrary to the traditional approach they were used to which focused on managing, directing, and controlling (MDC) (Lepatner, 2007; Kashiwagi, 2014; Kashiwagi et al, 2013; Kashiwagi et al, 2009). The philosophy of the Best Value Approach motivated the entire team to start their first BVA project: Telephone Facilities.

This paper will review the process of implementing the Best Value Approach on the Telephone Facilities project. The following topics are covered:

1. Necessary preparations for Best Value.
2. Evaluation and selection of the BV vendor.
3. Execution and project results.
4. Client and vendor evaluation and lessons learned from the BVA/PIPS Process.
5. Reflections and recommendations.

Necessary Preparations

In November 2015, the project group and the selection committee for the Telephone Facilities project was formed. The project group consisted of the project manager, an ICT network specialist and a Best Value purchaser/advisor. Except for the Best Value advisor (author of the paper), no one had experience with the Best Value Approach. The selection committee consisted of five people with different backgrounds and disciplines, however, none of the participants in the selection committee were technical specialists. The Best Value advisor conducted the interviews and facilitated the meetings where the selection committee had to reach a consensus.

In order to become a member of the project group or the selection committee, all members were selected and trained in the necessary paradigm shift required, from "MDC" to "listen, understand and align" (Kashiwagi, 2016; Kashiwagi, 2013; Rivera et al, 2016). The project manager and the ICT specialists were trained in Best Value by two A+ certified individuals in BV, Susan van Hes and Steven Bookelmann. The other members of the team were trained in the Best Value Approach throughout the project.

In the BVA, the client is not intended to instruct the vendors how to deliver the project but rather to identify what outcome they expect (Kashiwagi, 2016; Kashiwagi, 2013; Rivera et al, 2016). Vendors are then expected to utilize their expertise to create an optimal scope to fulfill the client's expectation. This change in paradigm requires the client to refocus their efforts in simplifying and communicating to the vendors what they want as an end product through a requirement (Kashiwagi, 2015; Sullivan, 2007; Kashiwagi, 2013). The municipality required several comprehensive sessions to create a good vision and project requirement. The formulation of accurate project objectives is essential to the preparation phase of a Best Value project (Kashiwagi, 2016).

Implementation

A lot of effort was put into formulating the project objectives. The first questions were: What is the purpose of the project? Which project results do we want? After several meetings and discussions, the main objective was decided to be: Mobile coverage (accessibility) in the entire area (North-West Groningen) for optimum functionality and safety. After the goal of the project was clear; the objectives and sub-objectives were formulated so that they challenged the market to show their expertise.

- Continuity. Ability to provide consistent coverage, availability and functioning of the telecom.
- Functionality and stability. Achieve an accessibility of at least 98% during regular opening hours; this accessibility will be realized in the first year of the contract.
- Usability. Achieve a user satisfaction of 80% within the first year of the contract.
- Manageability. Reach simple management activities while achieving manageable costs, hence the new situation costs should be predictable and transparent.

- Step by step innovation. Continuation of the current functionality and stability is an important goal. However, the municipality of Eemsmond wants a hosted solution on a step by step functionality renewal (Unified Communications).

Budget Estimation and Planning

The budget was estimated on what was paid in the current situation, but the client expected the costs should to be less in the new situation. After the publication of the Tender, the potential Vendors, including the project team and the selection committee, were educated once on the philosophy and methodology of the Best Value Approach [Performance Information Procurement System (PIPS) and Information Measurement Theory (IMT)]. The main purpose of this meeting was to educate the vendors thoroughly on the Best Value Approach and the emphasis to the vendors of the client's project goals. Seven different vendors attended this educational meeting. The response to the information was diverse, some of the vendors were very positive while some were very negative. It was clear that the vendors would have to adjust to the new paradigm and learn about the approach. The complete process schedule provides more details into the project's activities as seen in table 1.

Table 1

Tender Process Schedule

Stage of the tender process	Date
Publication Request for Proposal	April 27, 2016
Information meeting, Best Value	May 10, 2016
Deadline asking questions for the information notice	May 24, 2016
Sending information notice	May 31, 2016
Registration and opening of the Proposals	June 7, 2016
Interviews	June 21/22, 2016
Start Pre-Award phase	July 5, 2016
Final Award	September 15, 2016
Start contract	January 9, 2016

Evaluation and Selection of the Best Value Vendor

The submittals that were requested for the project included: project capability (including schedule), risk assessment and value added. Interviews were conducted with two key employees of the vendors' team. To find the Best Value vendor, the rating system 0, 5, and 10 was used. For this project, the price and quality was divided into a ratio of 25%/75% respectively (Kashiwagi, 2016).

The maximum quality ratios per criterion are as follows:

- Project Capability (including schedule) 20%
- Risk Assessment 15%
- Value Added 10%
- Interviews (2 * 15%) 30%

Phase 1: Proposals Rating
On June 7, four Proposals were received for the project. The Best Value advisor reviewed the Proposals to ensure regulations of validity, anonymity and budget were followed. Then the Proposals, excluding price, were forwarded anonymously to the members of the selection committee. These members rated the Proposals individually based on "dominant information". By following the Best Value philosophy "dominant information" brings consensus, decreases decision making and minimize risks (Kashiwagi, 2015; Sullivan, 2007; Kashiwagi, 2013). Knowledge expressed by non-technical performance metrics is a good example of dominant information. Prior to rating the Proposals, a separate training was held on May 24, 2016. The training reviewed the Best Value methodology, the guidelines to be followed when rating the vendors' submittals and practice cases.

After the review meeting, under supervision of the Best Value advisor, the selection committee reached a consensus rating for each of the vendors' submittals with the following conclusions (see Table 2):

1. Submittals that scored "0" were unanimously scored "0" in the individual ratings from each selection committee member.
2. Similarly, submittals that scored "10" were unanimously scored "10" in the individual ratings from each selection committee member.
3. The best and the worst submittals were dominant.
4. There was a discussion about the two vendors (A and B) who received ratings that were neutral, "5." The multidisciplinary composition of the selection committee worked well, especially for grading the project capability submittal. Through the conversation of the multidisciplinary team in which different points of view were exposed, the consensus scores were established (Table 2).

Table 2

Submittal Scores

Submittals	%	A	B	C	D
Project capability	20%	5	5	5	0
Risk Assessment	15%	5	5	5	0
Value Added	10%	5	5	5	0
Interview 1	15%	5	10	5	-
Interview 2	15%	5	10	5	-

Phase 2: Interviews
The key personnel at the interviews were the project manager and technical superintendent. The client determined these two individuals play a crucial role in the success of the project. The vendors were required to have scored a minimum average of "5" on their submittals to be invited to the interviews. This meant that Vendor "D" was not allowed to proceed to the interviews. All vendors were asked the same set of general questions. In addition to these general questions specific questions about each vendor's individual proposal was also used.

The interviews were held at a quiet location in the Municipality of Eemsmond. The Best Value advisor conducted the interviews, which were all recorded. At the end of the interview, the

selection committee was given the opportunity to ask one last question in order to reach a correct rating. All three vendors were interviewed in one day. Most individuals felt nervous at the start of the interview, but felt comfortable within five minutes.

The interviews were rated individually by the members of the selection committee after which the process in establishing a consensus score per interview was performed. Similar to the submittals, dominant information was used as the basis for each scoring and the supporting reasoning for all the scores was written down.

Vendor Ranking

After the consensus scores of the submittals and the interviews were finalized, the Best Value advisor revealed the pricing information. The prioritization was filled in and checked, and vendor B (RSE) was identified as the prioritized Best Value vendor. RSE had received the highest scores in the submittals and the interviews and had the lowest price (Figure 2). An example of the ambition and commitment of RSE is that they finished the project two months earlier than requested.

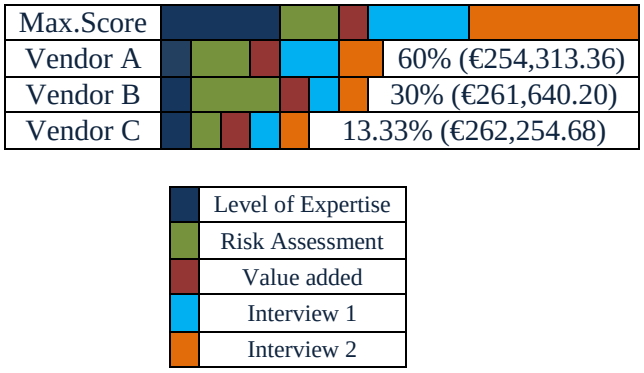

Figure 2: Point breakout per vendor.

Pre-Award

The Municipality of Eemsmond organized the Pre-Award kick-off meeting in which the project teams of RSE and the Municipality Eemsmond were invited. The kick-off started with a Best Value PIPS presentation by the client's Best Value advisor and indicated what the Pre-Award documents should contain:

1. Performance metrics (key performance indicators).
2. Detailed financial breakout of the project.
3. Detailed project planning.
4. List of all identified risks by the other vendors and solutions conceived by the vendor.
5. Response to any possible technical concerns or risks.
6. List of all uncontrollable risks/activities (not controlled by the vendor).
7. List of all assumptions.
8. List of roles and responsibilities.
9. List of accepted/rejected value added items.

After this, RSE took control of the meeting and presented a schedule (Figure 3) for the Pre-Award phase. Dates were made for when RSE would deliver certain submittals and time was scheduled for the project team of Eemsmond to get a thorough understanding of these submittals. There were two meetings scheduled with RSE and the project team of Eemsmond. The author of this article put a lot of effort into educating the project team of RSE and Eemsmond about the mindset of Best Value.

During the Pre-Award, it was a challenge to determine which of the value-added options (four) admitted by RSE, was worth accepting. In the end, the value-added options did not show enough dominant information to financially justify the client's approval. The Pre-Award period finished according to the schedule within six weeks after the kickoff meeting.

Execution and Project Results

After the signing of the contract, RSE started work immediately, fully utilizing the BV process by sending in the weekly risk report (WRR). The WRR is a weekly report which measures the project deviations from the initial vendor's plan outlined in the Pre-Award phase in terms of time, cost or quality and the source of the deviation (Kashiwagi, 2016). The vendor maintains and distributes the weekly to the client for review and approval. The project manager of Eemsmond would then be responsible to assess each deviation mentioned in the WRR and provide feedback through a rating of 1 (not satisfied), 5 (neutral) or 10 (satisfied). In total, four deviations were reported, all of which have received a client rating of 10.

The implementation phase has since finished (on time and on budget) with a customer satisfaction of 9 out of 10. The project is currently in the service/maintenance phase of the contract of which performance metrics are not available at the moment.

Client and Vendor Evaluation of the BV Process

The project group evaluated the Telephone Facilities project internally after the project was awarded to RSE. The overall picture of the tender process was positive and can be summarized as follows:

1. The tender was very successful in terms of time and cost.
2. The expert was found.
3. The high quality was received for a competitive price (lowest bidder).
4. Compared to the traditional system, the vendor is more committed to the project.
5. The degree of chemistry between people, both on the client side as well as between client and vendor in the Pre-Award period, can be described as HIGH.

Client Lessons Learned

1. Provide all relevant information. In case of doubt, if the information is relevant, provide it to vendors anyway.
2. If, during the tender process, new information is provided, mention the reason why it is added.
3. Give vendors time and space to learn.
4. Provide guidance for the submittals with information in your request of proposal.
5. Provide concrete information about the dates of the interviews.
6. Arrange an interview setting that is as relaxed and quiet as possible.
7. Mention, in the education session of Best Value PIPS, that it is not possible "to train someone on the content of the interview", but that it does make sense to prepare someone for the interview.
8. Do not shortlist when moving into the interviews. Allow all vendors to go to the interviews.
9. Adjust the interview questions to the different key personnel.

Vendor Lessons Learned

1. Know your client: is this a "real" Best Value project? Who is in the client project team?
2. Prepare the key personnel for the interview, for example: extensive discussion about the project and submittals, thinking in advance about possible interview questions and training the key personnel on interview techniques. It is important to prepare the interviewee.
3. Involve key personnel throughout the tender process so they are fully informed, and do not send an interviewee who does not understand the project.
4. Involve colleagues with Best Value experience who are not directly involved in the tender to review and help with the tender.

Best Value Observations

Philosophy

The Best Value philosophy teaches to see from the beginning to the end (Kashiwagi, 2016b), by doing this, potential risks are mitigated (Kashiwagi, 2016). Looking back on the process of the Telephone Facilities project not all risks were identified in advance.

One of the important lessons learned from this project is that better training is needed in the philosophy of Best Value for the personnel of Eemsmond who are outside of the immediate project organization. The shift from 'management, direction, and control' to 'listen, utilize and align' is especially important and difficult to understand for some. Education helps stakeholders to listen to and understand the project manager in cases of unforeseen risk. Thus, stakeholders will be focused on how they can help the project manager, rather than managing, directing and controlling the project manager. This will ensure that unforeseen risks are mitigated as soon as possible. Therefore, proper use of the weekly risk report requires it to be sent to the correct

people (stakeholders and managers) and those people need to be trained in the Best Value philosophy.

Project Team Composition

It requires the necessary attention to compose the right project team and the right selection committee. This is a critical step for the client because not everyone in the organization will understand and participate in the paradigm shift of "manage, direct and control" to "listen, utilize and align," (Kashiwagi, 2016). It is important to have a mixed selection committee, this means having a team that contains experts with different backgrounds. A multidisciplinary and balanced selection committee with a minority of technical specialists and preferably people who can think in terms of processes, contributes to an objective assessment.

Pre-Award

The Pre-Award period of the Telephone Facilities project was successfully completed in six weeks. It is important in the Pre-Award stage to manage the expectations between vendor and buyer. The key is that the vendor pre-plans this period. Staying in the right role as a client or a vendor is an important point of attention. The different roles for the client and the vendor are very clearly defined in the Best Value process: the vendor is in the lead, it is their plan, and the client supports the vendor to make their plan to be as complete and efficient as possible (Kashiwagi, 2016). Education on the concepts of Best Value is necessary in this period. The technically educated people on the client side have to be trained to ask questions instead of trying to re-make some components of the vendors plan.

Pre-planning of the Pre-Award period helped the project members; it was clear from the beginning what the purpose of this period was and what input was needed from the client's representatives. It worked very well to organize an internal meeting before the meeting with the vendor. In this meeting MDC was turned into asking questions and naming concerns.

Conclusion

To achieve the municipality's goals, the Best Value Approach was identified as the optimal system. The BVA approach achieved the following results:

1. An expert was found with a high-quality solution.
2. Highest quality and lowest bid amongst competitors and below the existing costs of the municipality by 27%.
3. Implemented solution on time and on budget with a customer satisfaction of 9 out of 10.
4. An estimated time savings of 50% by the team (6 employees) over the traditional tenders.

The conclusion of this review details how the results of the Telephone Facilities project provides several valuable lessons in regards to the Best Value philosophy and methodology. The author of this paper strongly recommended that the BVA was a major improvement to the way the municipality selects their Best Value supplier.

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A Survey of the Prevalent Forms of Corruption in the Construction Industry in Botswana

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The Construction industry is contributing immensely towards social and economic developments around the world. However the industry is susceptible to corrupt practices because it involves substantial capital investments. Every phase of the construction process: planning and design, pre-qualification, tendering, project execution, operation and maintenance is attractive to corruption. The effects of corruption are quite substantial in terms of quality, time and cost of a project. The objective of this study was to identify the most prevalent form of corruption in the Construction industry in Botswana. The study was quantitative and conducted through literature review on the topics related to corruption in the Construction industry followed by questionnaire survey. A total of 81 questionnaires were distributed among the relevant employees of the Directorate of Building and Engineering Services (DBES), Southern District Council (SDC) and contracting organizations. Sixty properly filled questionnaires were returned giving a response rate of 74.07%. Cronbach's Alpha equals 0.939 for the entire questionnaire which indicates an excellent reliability of the entire questionnaire. Rank-order Analysis was performed to examine the professionals' perceptions of the most prevalent form of corruption in Botswana's construction industry The results indicate that bribery in form of cash inducement, gifts, favors, and kickbacks rank highest (RII= 0.65) and constitute the most prevalent form of corruption in Botswana's construction industry.

Keywords: Corruption, Bribery, Construction Industry, Botswana.

Introduction

Botswana's economy has grown steadily over the years, from being one of the poorest to one of the most successful countries in sub-Saharan Africa. Olowu (1999) attributed the country's growth to the commitment of the political leadership to liberal/multiparty democracy or consensus politics and to sensible economic policies, rapid and sustainable economic growth and efficient central state. Botswana has never experienced military rule and there has been five yearly multiparty elections since 1966, when it became independent.

Botswana public service was perceived to be generally efficient and incorruptible until the early 1990s, when a number of major corruption scandals rocked the country's public service. This included illegal sale of public land, construction of high cost houses for sale which there was no prospective demands, and a loan from the National Development Bank by high-ranking persons that actually led the bank to ruin. Most of these scandals were revealed by independent public media, which led to official enquiries. The enquiries did not only establish the truth about the presence of corruption, but also led to the resignation of a number of Ministers and demonstrated the general pattern of corrupt activities in Botswana (Olowu, 1999). Botswana, as well as other developing countries, experienced theft and fraud perpetrated by public officials. Towler (2007) remarked that corruption of government officials abound at all levels of the public sector,

including theft of government funds at alarming rate. According to Good (1994), examples of corruption in Botswana include:

- One of the former ministers of Local Government and Housing, who was found to have used his position to benefit his friends.
- Construction of 407 high cost houses had been planned on hillside at Lobatse, though there was little or no market for such accommodation, for which the Botswana Housing Corporation paid P8.5M for professional service for the design of the project.
- In 1992, Spectra Botswana received P12M to build new Botswana Housing Corporation headquarters before the contract was finally cancelled. It was found that "the ultimate administrative responsibility," was borne by one of the former Permanent Secretaries in the Ministry, who was also the Chairperson of Botswana Housing Corporation, while one of the former Ministers carried the political responsibility for the massive corruption.

According to Sunday Standard (2011), there was an alleged corruption at Botswana Development Corporation (BDC) regarding Glass Manufacturing project at Palapye. The project was a joint venture between BDC and Fengyue Glass Company. There was no formal tendering to identify or select the contractor. It was also discovered that the contractor did not have technical expertise or any experience on glass manufacturing. The company failed to raise equity as requested by BDC. The audit revealed that the contractors were overpaid and, in some instances, paid for supplies not delivered.

Transparency International persistently touts Botswana as a "regional highflyer," because of its' consistent number one spot in the corruption perception index (CPI) for the Sub-Saharan Africa. This has been a boost for government willingness to reduce or exterminate corruption. In a budget speech, it was clearly stated that the Transparency Internal CPI result for Botswana "needs to be nurtured and sustained by robust anti-corruption policies and strategies" **(**Botswana Government, 2010). This laudable ambition is yet to yield remarkable improvement in some affected sectors of the economy especially the construction industry where projects continue to fail as measured by cost and time overruns, abandonment and low quality work.

Girling (1997) stated that corruption does not actually disappear as the country develops, rather it takes a new dimension. The research aims to obtain a clear overview of the nature and level of corruption in the construction industry in Botswana with the objective of determining the most prevalent form of corrupt practices in the industry.

Literature Review

According to Sohail and Cavill (2008), the global construction market is worth around US$ 3,200 billion yearly. This market represents 5-7% in developed countries and around 2-3% of GDP in lower income, developing countries. The construction industry has an international reputation for corruption, asset misappropriation and bribery. Transparency International's Bribe Payer Index continually shows corruption to be greater in construction than any other sector of the economy.

The Construction Industry is the Most Corrupt

Figure 1 shows the result of a comparative survey carried out on many industries, including the construction industry (Kenny, 2007). It shows that the construction industry is the most corrupt on a scale from zero to ten. A low score indicates a high corruption rate, while a high score indicates a low corruption rate. The construction industry is ranked lowest, at a score of around 5.2 and is, thus, considered the most corrupt industry.

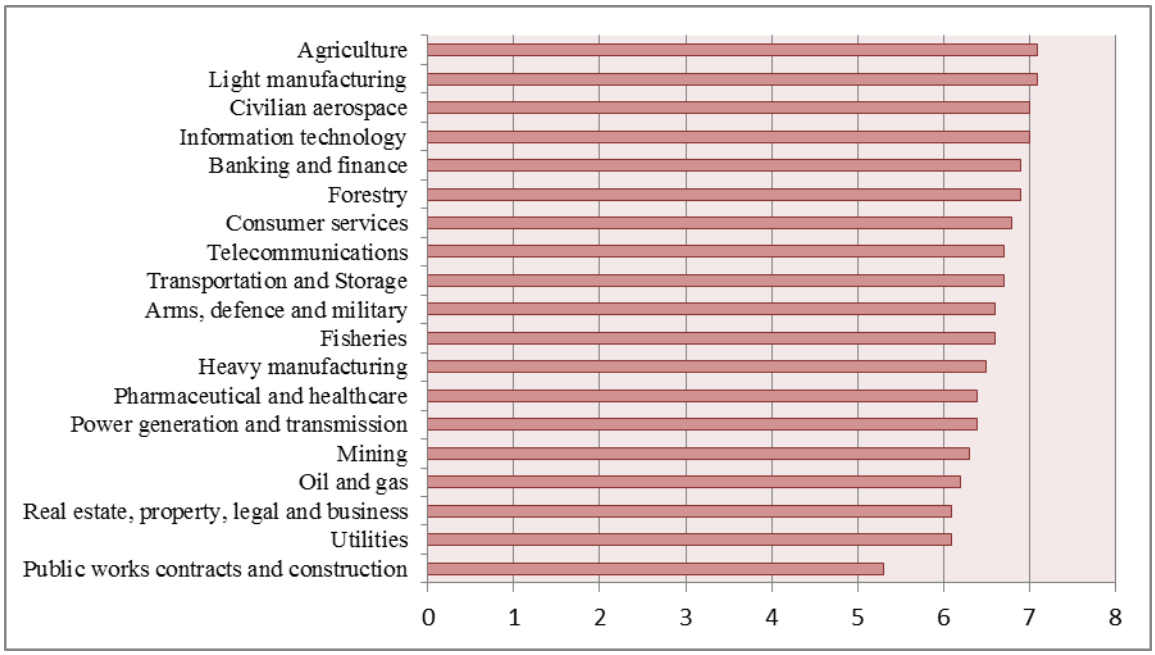

Figure 1: Transparency International's Perception of Corruption by Industry; from 0 (corrupt), to 10 (uncorrupt).

Dorn et al. (2008), suggests that corruption does not happen in a vacuum, but it involves a medium to thrive. That is, corruption takes place when public officials, entrusted with procurement collude with the third party (contractor) in pursuit of personal interest which traditionally involves bribes and other fraudulent practices. Soreide (2006) explained that procurement procedures do not guarantee a superior combination of price and quality. Procurement procedures behind large projects like the construction of a highway, a tele-communication network, etc., can be manipulated in several different ways. Furthermore, large infrastructure projects appear particularly prone to political intervention, addressing, for instance, regional or distributional considerations, unemployment and protection of domestic industry.

The procurement procedure/process occurs in three stages which are as follows:

- Preparatory stage: When procurement needs, budget and question of procedure are settled.
- Solicitation: Bidding and selection.
- Execution of the contract stage: Work is done and delivered.

Risks of Corruption in Different Stages of the Construction Industry

Preparatory Stage

Corruption may potentially take place at any stage of the stages of procurement process. Corruption opportunities arise as decision are made about whether and how the provision should be applied in the light of the needs of the procuring entity, the type and scale of work envisaged, the criteria to be met by successful bidders, the availability of potential bidder, the procedure to be followed and so on. Contractors may be involved in shaping the requirements, either through their previous work through helping the procuring entity to draw a specific contract. Decision made at this stage will decisively shape scope and terms of eventual contract. Such decisions include the choice of procedure, justifications for using open, negotiated, emergency procedure, the possibility of breaking down the work in to small packages and time frames, drawing up specifications and pricing of the work to be delivered .Corruption risks that may happen include improper involvement of contractors, fixing specifications or criteria so to unduly narrow the field, setting an unrealistically low price so as to discourage other bidders and the entering in to a negotiated bid with one favored contractor (Dorn et al. 2008). In the construction industry architects prepare drawings to suit their friends, information is leaked to quantity surveyors about an upcoming project through the evaluation of initial cost estimates and they also leak information to their colleagues in the construction sector who at bid tender period will have advantage over those who did not know the probable value or contract sum of the upcoming project. Officials plan in favor for high valued projects which may not address an immediate or long term socioeconomic problem; over designing and overpricing projects because of personal gains; and ignoring an unfavorable environmental impact assessment/planning proposal or approval **(**Osei Tutu et al. 2010).

Solicitation of Bids Stage

At this stage, there is evaluation of tenders and selection of best evaluated bidder. Decisions are made about suitability of specific bidder; checks should be made about suitability of specific bidder. Checks should be made to see if tenderers are independent and the selection criteria is done air manner in order to choose a successful tenderer (Dorn et al. 2008). Among the most corrupt practices issues faced by the construction industry is bias in tendering or unethical tendering practices (Ameh and Odusami, 2010). Zou (2006) stated that the uncompetitive tendering practices include inappropriateness of tender evaluation criteria, preferential treatment of tenderers, disclosure of baseline price of project and other confidential information and integrity of members of tender evaluation committees.

Contract Execution Stage

Once the contract has been agreed and signed, in principle, there may be further negotiations on details of scope and price. Depending on the procedure used, these negotiations may be financial and may be quite considerable. Prolongation or extension of contract may be agreed without further competition. There is high chance of “scope creep” at this stage, which either may be hidden in the tender but not anticipated by the procuring entity or alternatively may be engineered by the tender in order to obtain an extension. In certain circumstances the procuring

entity may prefer to issue another contract, rather to admit that things are going badly. In some cases, change of staff may mean that procuring entity do not understand that they are being manipulated, in other cases they may be conflicts of interest and corruption. At this stage project deliverables should be closely monitored in order to assess to what extent specifications are met (Dorn et al. 2008). Among the examples of corruption and unfair practices witnessed in South Africa, according to Bowen et al. (2012), were in terms of:

1. Materials – the contractor lies about materials used or uses inferior materials and loss of materials on site;
2. Professional dishonesty – poor practices by consultants; inexperience; blaming
    a. Contractors for incompetence; deliberately increasing contractor cash flow through unmerited payment awards, and recommending friends for tender awards;
3. Documentation – poor and incomplete
4. Poor workmanship by contractors;

Cost of Corruption in Public Procurement Stage

The cost of public procurement is difficult to measure quantitatively due to the environment in which it takes place. Given the massive amount of money spent on public contracts, no one doubts that corruption in procurement has an immense impact on the effectiveness of government investments. Transparency International estimate that damage from corruption can represent an average of 10-25 % and in worst cases it represent as much as 50 % of a contract value. In Morocco, despite reforms to the procurement system, recent calculations by industry experts suggested that corruption still costs the country about 5 % of the value of each contract. In the Philippines business insiders have speculated that this cost may reach up to 50 % (Transparency International, 2010)and thereby inflates contracts cost by about 20-30 per cent (Mawenya, 2008**)** cited by Ameyah et al. (2012**).** Another survey reported that the cost of corruption is estimated at about US$ 148 billion per annum in Africa (World Bank, 2003) cited Ameyah et al. (2012b).

Corruption in public procurement is not just about money, it cost lives. This happens when the execution of a construction contract is flawed leading to a building collapse. This has happened in both developing and developed countries. For example, the high death tolls as a result of the devastating earthquake in Turkey in1998, India in 2001, China in 2008, and Haiti in 2010 were partly blamed on alleged corruption in the construction industry in relation to public buildings, including schools and hospitals (Transparency International, 2010).

Corruption during Construction Project Life-Cycle

Corruption can happen at any stage of construction project life cycle as illustrated with examples in Appendix 1 (Sohail and Cavill, 2008). Strombom (2001) as cited by Sohail and Cavill (2006) argued that corruption generate immense opportunities for payoff with comparatively low risk of detection and punishment. This is a key problem in the construction industry, which is typically adversely affected by delays, disruption and changes leading to increased costs, these incidences of corruption can be obscured by other cost overruns meaning that corruption goes undetected. Pricewaterhouse Cooper (2003) found that the problem of corruption often comes to light as a

result of either whistle blowing or accident discovery and suggest that that construction companies tends towards the view that the value of the defrauded assets is often less than the costs of implementing a robust and effective risk management system.

There are many cases of uncovered corruption in the construction industry. The Deputy Mayor of Beijing in charge of urban development and Olympic projects was removed from his office in 2006 along with other Vice mayors because of corruption allegations. In the same year an audit of 21 highway Chinese high way construction with combined value of US$ 605 million found that a third of the amount had been misappropriated by government officials (Sohail and Cavill, 2008).

In Botswana, a quantity surveyor employed by the Department of Building and Engineering Services appeared before court on charges of forgery and supplying false information to a person employed in the public service. This followed removal of the consultant's recommendation from his report and replacing it with her own thereby diverting over P11 million (USD1.1 million) tender to a company which was disqualified by the consultant **(**DCEC, 2006).

Corrupt Practices in International Construction

According to Azhar et al. (2011), published literature has indicated the presence of unethical conduct and corruption in the construction sector of both developed and developing countries. Here are some examples:

- Fails Management Institute (FMI) conducted a study for the Construction Management Association of America (CMAA) entitled "Survey of Construction Industry Ethical Practices" (Fails Management Institute, 2004). The study focused on the activities of construction project owners, architects, engineers, construction managers, general contractors, and subcontractors. The results were quite alarming. For instance, when respondents were asked whether they had personally experienced, encountered, or observed industry-related acts or transactions that they would consider unethical in the last 12 months, an overwhelming 84 percent said "yes." In addition, 34 percent indicated that they had encountered such acts "many times." A majority (63 percent) of survey respondents felt that the construction industry was tainted by the prevalence of unethical acts. Similarly, 61 percent of the respondents thought unethical behavior was affecting the cost of completing the projects.
- The Chartered Institute of Building (CIOB, 2006) conducted a survey to gather views on corruption within the UK construction industry. It was found that there was a great deal of variation in the way that respondents perceived the nature and extent of corruption. It was acknowledged, however, that 41% of those surveyed had been offered a bribe on at least one occasion.
- Hartley (2009) reported that within the Australian construction industry, anticompetitive practices especially related to workplace practices are common. These practices have included collusive bidding, lack of honesty and fairness in business relationships, and poor or non-existent occupational health and safety practices.
- A study by Ling and Hoang (2010) indicated widespread corruption in foreign funded public projects in Vietnam.

Reason Why Construction is Prone to Corruption

Rodriguez et al. (2005) highlighted that construction projects usually involve a large number of participants in a complex contractual structure. Construction projects structure can be very complex depending on the magnitude and type of the projects. The client is linked to source of finance (bank), project engineer, consultants, main contractor etc. The main contractor is linked to specialist sub-contractors and the sub-contractors are linked to suppliers.

The 'main contractor' is likely to be a private sector construction or engineering company, which may then subcontract key parts of the project according to its own guidelines for awarding contracts. Subcontractors may in turn sub-subcontract parts of their work, and sub-subcontractors may purchase equipment and materials from suppliers, or award further subcontracts.
The following features of construction projects according to (Standsbury, 2005**)** make them particularly prone to corruption (Appendix 1).

Methodology

There are many players involved in the construction industry in Botswana. They include professionals such as quantity surveyors, architects, project managers, engineers and procurement officers. The targeted population for this research therefore consists of the professionals employed by the Department of Building and Engineering Services (DBES), Southern District Council (SDC), and construction companies that were involved with DBES and SDC projects. DBES is the umbrella of construction project procurement in Botswana since it handles all mega-projects hence was selected to represent the client. Local authorities are also given fair amount of budget for implementation of small to medium projects and it is for this reason that SDC was also selected as a research subject. The construction companies targeted were those registered with PPADB, an organization responsible for registering and grading all companies dealing with project procurement in Botswana. These construction companies also ought to have been registered and engaged by DBES or SDC to procure construction projects.
A pilot study was performed to test the adequacy and validity content of the survey instrument (questionnaire) and feasibility of its administration with a view to eliminating any ambiguities. It was discovered at this stage that some potential respondents mainly DBES and SDC were not willing to participate in the study despite the reassurance of confidentiality in the questionnaire. This was mainly due to the sensitiveness of the subject matter which is corruption. Some officers requested that permission should be sought from the chief executives of their organizations before responding to the questionnaire. Most of the participants did not want their identity known and were of the opinion that revealing their names would prompt investigations even though the problem was addressed by in the questionnaire by indicating that provision of name or identity is optional. The refusal to participate in the subject matter by a proportionate number of targeted employees was traced in part to the fact government officers in Botswana signed Oath of Secrecy, which stipulates in the Public Service Act, 26:01 and of the Penal Code Chapters 08:01 that "any information gained as a result of employment shall not be divulged except in the course of the duty or authorized by superior officer." However some of employees were willing to participate in the survey inasmuch anonymity is observed.

By the nature of this research, survey questionnaire was the most suitable approach for collecting data. In the pilot study five questionnaires each was distributed at DBES and SDC. A questionnaire each was distributed in five Construction companies. A sizeable number of construction companies were also not willing to participate in the study. However five of the companies took the questionnaire. In total, only seven respondents filled the questionnaire and this was made of two DBES, three SDC and two construction company staff.

Due to lack of interest among large number of the targeted population and low questionnaire response rate during the pilot study it was deemed appropriate to resort to purposive sampling technique. Architects, quantity surveyors, engineers, project managers, engineers and procurement officers were purposefully sampled according to their experience in project execution and willingness to participate in the research and were issued with the questionnaire. A total of 81 respondents were issued with questionnaire and they consisted of 27 Department Buildings and Engineer Services employees, 27 Southern District Council employees and 27 employees of Construction companies. A total of sixty (60) respondents out of the targeted respondents comprising of seventeen (17) DBES twenty five (25) SDC employees, twenty five (25) SDC employees and eighteen (18) construction companies' employees participated in this study as shown in the Table 3.1**.** The response rate was high mainly because the participants were assured that their responses and personal details shall not be divulged to anyone considering the sensitivity of the subject matter.

Table 2

Sample Size (Legae, 2015)

Respondents		**Number of Distributed Questionnaires**	**Number of Respondents**	**Response Rate (%)**
Client	DBES employees	27	25	92.59
	SDC employees	27	17	62.96
Contractor's employees		27	18	66.67
Total		**81**	**60**	**74.07**

The questionnaire was divided into two parts. Part A was the demographics of the respondents while part B was ranking the forms of corruption in the construction industry as encountered in literature and confirmed by the respondent professionals during the pilot study. Twenty of such forms of corruption were the subject of ranking as shown in Table 4. The strength of respondents' opinion was elicited by using 5 point Likert scales to show the frequency they thought each form of corruption occurred in the Botswana Construction Industry.
The questionnaire was made up of the following sections:

1. Section A contains general informationof the respondents and their organization, such as the experience of the respondents, their position within their organization,
2. Section B contains information about perception of the nature and overall level of corruption and forms of corruption prevalent in the construction industry as extrapolated from the literature. Twenty factors as listed below were included in part B of the questionnaire for rating on the Likert scale of one (1) to five (5):

- Under bidding.
- Leaking of information to a preferred bidder.
- Employment of illegal workers.
- Negligence like late and short payments, poor quality and inadequate information, lack of supervision, lack of safety ethics, bad documentation unfair treatment of contractor
- Bribery inform of cash inducement, gift, favour and kickback to obtain contract.
- Inclusion of false extra cost to contract claim.
- Embezzlement.
- Collusion.
- Collusive between bidders for market sharing purposes
- Bid rigging.
- Production of fraudulent time sheets.
- Conflict of interest.
- Cover pricing.
- Bribery to obtain planning permit.
- Extortion.
- Bid shopping.
- Bribery to obtain planning.
- Production of fraudulent invoices.
- "Bid shopping".
- Fraud.

The relative importance index (RII) is computed from the equation:

$$\mathrm{RII} = \frac{\sum W}{A * N}$$

Where W is the weighting given to each factor by the respondents (ranging from 1 to 5), 'A' is the highest weight (i.e. 5 in this case), and N is the total number of respondents. The higher the value of RII, the more severe the factor on corruption.

Cronbach's coefficient alpha

The Cronbach's alpha (α) is used to measure the reliability of the questionnaire between each field and the mean of the whole fields of the questionnaire. Cronbach's alpha (α) is a test reliability technique that requires only a single test administration to provide a unique estimate of the reliability for a given test. Cronbach's alpha (α) is the average value of the reliability coefficients one would obtain for all possible combinations of items when split into two half-tests. It tells how accurate and precisely the measurement is made on a certain variable by a research instrument. The normal range of Cronbach's coefficient alpha value is between 0.0 α and 1.0, and the higher values reflect a higher degree of internal consistency.

Cronbach's alpha, $\alpha = k\,[1-(\sum s_i^2 / s_t^2)]/\, k\text{-}1$.

K is the number of items in the questionnaires, s_i^2 is the overall variance of the questionnaires and s_t^2 is variance for i^{th} item in the questionnaires. Cronbach's Alpha equals 0.939 for the entire questionnaire which indicates an excellent reliability of the entire questionnaire. The spread of the respondent by percentage were 41.7% from the Local Authority, 28.3% from DBES and 30% from construction companies. Their demographic information in terms of experience, professional affiliation, and qualification are as shown in Figures 1a through c.

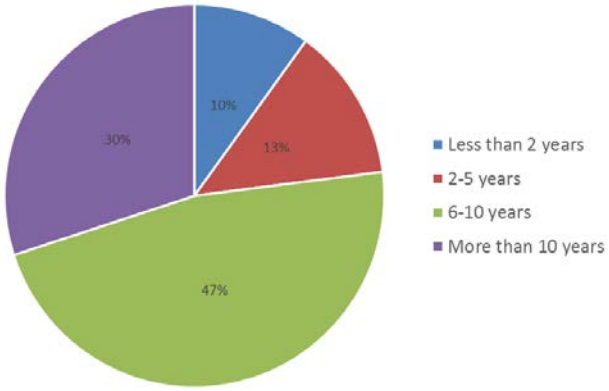

Figure 1a: Experience of Respondents in years.

From Figure 1a, about 30% of the respondents had more than 10years experience in the built environment, 47% had six to 10 years' experience, 13% had two to five years' experience and only 10% had below two years' experience. It can be deduced from this figure that the respondents had enough years of experience in the built environment to be aware of corrupt practices in the sector.

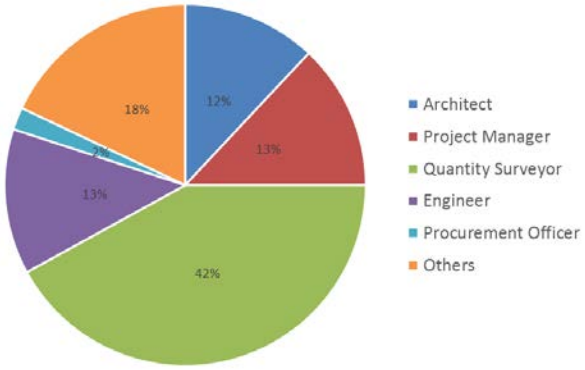

Figure 1b: Profession of Respondents.

Figure 1b shows that 82% of the respondents are personnel in the key areas of construction activities. They are made up of 42% quantity surveyors, 18%architects 13% engineers and 2%procurement officers. The rest 18% are either accountants or economists providing services to the organizations. Therefore in addition to experience, the respondents are professionals capable of giving authentic information about transactions in the construction industry.

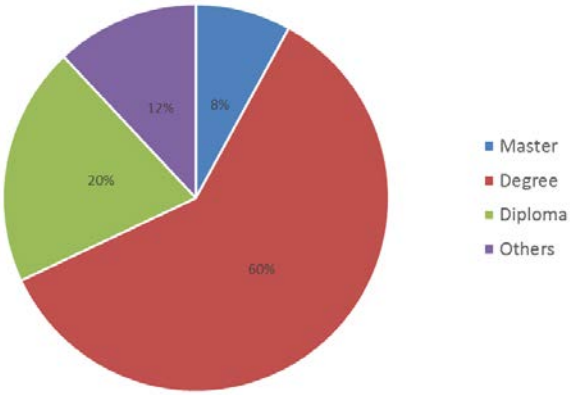

Figure 1c: Qualification of Respondents.

Figure 1c shows that 60% of the respondents have bachelor's degree while eight percent additional have master's degree. Twenty percent have higher diploma while 12% either have ordinary diploma or high school certificate. To a large extent the respondents have enough educational background to understand and discuss the affairs of the construction industry. With requisite background (education, experience, professionalism), it can be summarized that the respondents are competent enough to contribute to Corruption issues in the construction industry.

Earlier in the pilot study, all the respondents were of the opinion that corruption existed in one form or the other in Botswana's construction industry. Ranking the forms of corruption in part B of the questionnaire gave the result shown in Table 4.

From equation, 1 the ranked result of the RII is shown in Table 4.

Table 4

RII for forms of corruption encountered in the construction industry.

How often have you encountered the following forms of corruption in the construction industry?	RII score	Rank
Bribery inform of cash inducement, gift, favor and kickback to obtain contract	0.65	1
Under bidding	0.64	2
Leaking of information to a preferred bidder	0.63	3
Employment of illegal workers	0.60	4
Negligence like late and short payments, poor quality and inadequate information, lack of supervision, lack of safety ethics, bad documentation unfair treatment of contractor	0.60	5
Conflict of interest	0.59	6
Collusion	0.59	7
Collusive between bidders for market sharing purposes	0.54	8
Bid rigging	0.54	9
Production of fraudulent time sheets	0.53	10
Inclusion of false extra cost to contract claim	0.53	11
Cover pricing	0.52	12
Bribery to obtain planning permit	0.51	13
Embezzlement	0.50	14
Production of fraudulent invoices	0.49	15
Bid shopping	0.49	16
Extortion	0.46	17
Change order games	0.43	18
Withdrawal of tender	0.42	19
Fraud like illogical request for time extension, theft of materials	0.40	20

The table showed that bribery in form of cash inducement, gifts, favor and kickback ranked number one with RII = 0.65, underbidding to obtain contract ranked second with RII = 0.64) while leaking information (RII = 0.63), ranked third. These are the most common form of corruption risk factors in the construction industry of Botswana from the point of view of the professionals from DBES, SDC and the contracting firms.

Conclusion

The objective of this study was to investigate the prevalent forms of corruption in the construction industry in Botswana in rank-order of their frequency of occurrence using Likert-type scale. Test of reliability of the questionnaire showed a Cronbach's Alpha of.9.39 for the entire questionnaire which indicates an excellent reliability of the entire questionnaire. The result suggests that all respondents believe that corruption is present in the construction industry in Botswana despite the country's highest rating on the Transparency International corruption perception index. The most frequent form of corruption is bribery which manifests itself as cash inducement, gift, favor and kickback to obtain contract. This was followed by underbidding to obtain the work and thirdly, leaking information to preferred bidder. These results are useful information to both the clients and the contractors at all stages of infrastructure projects.

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Appendices

Appendix 1: Examples of corruption in the different stages of infrastructure delivery

Stage of service delivery	Key stakeholders	Examples
Project selection	• Public clients • Private clients	• Corruption can negatively affect the selection of projects. For example, corruption can divert resources away from social sectors and toward major infrastructure projects. • Corruption may also encourage the selection of uneconomical projects because of opportunities for financial kickbacks and political patronage.
Planning stages	• Public clients • Private clients • Financiers • Legal advisors	• Project used as vote winners/opportunities for personal gain not on basis of priority/availability of financial resources. • Planning in favor of high value infrastructure, white elephant projects against the interest of the poor. • Project requirements may be overstated or tailored to fit one specific bidder.
Inspection stages	• Regulatory authorities	• Weak oversight and supervision mechanisms have been created that would prevent detection of fraud and corruption. • Kickbacks can be given to persuade inspectors to turn a blind eye to slow implementation of projects, unfulfilled contract requirements, and other instances of malpractice.
Design	• Design consultants • Public clients • Private clients	• Corrupt selection of consultants for feasibility studies, preparation of specifications/bid documents. • Overdesigned and overpriced projects to increase potential corrupt earnings during implementation. • Bribe for favorable environmental impact assessment/planning proposal/approval. • Project design has been manipulated to benefit particular suppliers, consultants, contractors, and other private parties. • The timing of the project has been altered to suit vested interests
Bid and contract signing stage	• Contractors • Subcontractors • Suppliers	• Political parties levy large rents on international businesses in return for government contracts. • Officials take percentages on government contracts. • Officials receive excessive “hospitality” from government contractors and benefits in-kind. • Kickbacks for construction and supply contracts. • Lack of competitive/inequitable contract practices. • Inappropriate bidding procedures; excessively short bidding time or insufficient or inadequate advertising of tender. • Corrupt practice on the part of bidders _e.g. unjustified complaints, misleading bisect. • Collusion among firms or between public officials and bidders. • Bid rigging in construction contracts can be facilitated by corrupt project managers and quantity surveyors, people who are supposed to be policing contracts and making sure the clients get value for money. • Compensation payments included in the tender price: when two firms collude, and one prices itself out of one of the jobs and receives a compensation payment from the other as a reward. • Cash-plus contracts enable unscrupulous firms to inflate the value of the contract
Construction	• Contractors • Subcontractors • Suppliers	• Changing subcontract party after receiving bribes. • Cutting corners, ignoring rules, bypassing procedures. • Payment for equipment, materials or services which were not supplied. • The provision of equipment or goods of lower than specified quality; typical examples include lesser cement or steel reinforcements. • Concealing substandard work. • Bribe the relevant official to certify that the work was done according to specification. • Unjustified complaints from contractors as a way to obtain unjustified contract

		price increases. • Duplication of payments, alteration of invoices, lack of supporting records, ineligible payments, overbilling, misuse of funds, ie, for purposes other than those aligned to project needs, misappropriation of discounts from suppliers/contractors, unauthorized payments, etc. • Unauthorized use of project property. • Theft of materials, equipment, or services.
Service delivery	• Public clients • Private clients • Contractors • Subcontractors	• Ghost/absent workers. • Siphoning off supplies to market. • Favoritism in hiring/promotions. • Use of contacts/money to get better/faster service or to prevent delays. • Elite capture of infrastructure services
Maintenance and management stages	• Public clients • Private clients • Contractors • Subcontractors • Suppliers	• Corruption in procurement of equipment and spare parts. • Withholding needed approval/signatures of gifts/favours. • Corruption increases costs meaning lack of resources for operation and management. • Bribes to win operation and management contracts/personnel appointments. • Lower standard of construction creates need for expensive repair and maintenance

Source: Sohail and Cavill (2008)

Appendix 2
Features of Construction projects that make them particularly prone to corruption.

1. Size of projects

1.1. While construction projects vary in scale, infrastructure projects in particular are often huge. The costs of dams, power stations, industrial plants and highways can run into billions of dollars. It is easier to hide large bribes and inflated claims in large projects than it is in small projects.

2. Uniqueness of projects

2.1. The fact that many major construction projects are one off makes costs difficult to compare, which in turn makes it easier to inflate costs or hide bribes.

3. Government involvement

3.1. Most infrastructure projects are government-owned. Even privatized projects require government approvals for planning or agreements to pay for end-product use. The industry tends to be heavily regulated at both national and local government level. Numerous permits are often required. Where there are insufficient controls on how government officials behave, their power combined with the structural and financial complexity of the projects makes it relatively easy for officials to extract bribes.

4. The number of contractual links

4.1. While there are numerous variations to the project structure outlined above, the contractual cascade could easily have more than 1,000 links, each depending on other contractual links in the chain. Every single link provides an opportunity for someone to pay a bribe in exchange for the award of a contract. In addition, work and services are exchanged for payment in relation to every contractual link. Every item of work and every payment provide further opportunities for bribes to be paid in return either for certifying too much work, certifying defective work, certifying extensions of time or paying more expeditiously.

5. The number of phases makes project oversight difficult

5.1. Projects normally have several different phases, each involving different management teams and requiring handovers of the completed phase to the contractors undertaking the next phase. For example, a power station project may have the following phases: demand determination, choice of type (hydroelectric, coal, oil, gas), design, excavation, foundations, civil works, building works, equipment manufacture, equipment erection, commissioning and operation. Even if a single contractor undertakes all the project's phases, it will normally subcontract different elements of the task to individual subcontractors, which creates difficulties in control and oversight.

6. The complexity of projects

6.1. Because of project complexity, the interrelationship between contractors and events is often uncertain. People working together on project frequently appear not to know, or to disagree upon, the reasons why something has gone wrong, or why costs overrun. This makes it easier to blame others and to claim payment, even when such claims are unjustified. Bribes and inflated claims can easily be hidden and blamed on other factors, such as poor design or mismanagement. Complexity also generates reasons to pay bribes since decisions on cause and effect and their cost consequences can have an enormous

impact.

7. **Lack of frequency of projects**
   7.1. Major projects come at irregular intervals. Winning these projects may be critical to the survival or profitability of contractors, which provides an incentive to contractors to bribe.

8. **Work is concealed**
   8.1. Most components in construction end up being concealed by other components. Structural steel may be concealed by concrete, brickwork by plaster, engineering components in casings, and roof structures by cladding. The industry places an enormous dependence on the individuals who certify the correctness of the work done before it is concealed; once an item is concealed, it can be very costly or difficult to check if it was completed to the required standard. This cost and difficulty creates an incentive for contractors to do defective work or use inferior materials and to bribe the relevant official to certify that the work was done according to specification.

9. **A culture of secrecy**
   9.1. There is no culture of transparency in the construction industry. Costs are kept secret even when it is public money that is being spent. Commercial confidentiality takes precedence over public interest. The routine inspection of books and records that might uncover malpractice does not normally occur.

10. **Entrenched national interests**
    10.1. Local and national companies often have entrenched positions in their own market. These positions have often been cemented by bribery. International companies seeking to enter these markets may find it impossible to win work unless they pay a bribe.

11. **No single organization governs the industry**
    11.1. Construction brings together a wide range of professions, trades and specialist contractors, leading to varying standards of skill, integrity and oversight. The professions include architects, engineers, surveyors, accountants and lawyers; and the trades include machine operators, scaffolders, bricklayers, electricians and plumbers. Contractors' skills range from excavation to insulation and from generators to cooling systems. Each profession or trade may have a different professional association, with different codes of conduct and levels of enforcement of these codes. No single organization has overall responsibility.

12. **Lack of due diligence**
    12.1. The scale of funds involved in major infrastructure projects places great influence in the financing bodies that determine whether a project goes ahead, and which companies win the contracts. Commercial banks and global or regional development banks provide most of the funds; while government sponsored export credit agencies may underwrite risky international projects. Their frequent lack of due diligence on participants in construction projects allows corruption to continue.

13. **The cost of integrity**
    13.1. It is striking how many people working in the construction sector either accept the status quo, or makes no attempt to change it. Bribery and deceptive practices are so engrained that they are often accepted as the norm. Bribery is frequently a routine business cost that many companies expect to include in the contract price. The fact that so many businesses in construction routinely pay bribes or engage in deception makes it very costly for any one company to act with integrity since that company would risk losing out to its less scrupulous competitors. As a result, many companies find themselves in a vicious circle in which they engage in corruption, often reluctantly, as a defensive measure against the corrupt practices of other companies.

Source: Stansburry (2005).

Synthesis of Methods and Measures for Determining Value of Transportation Research

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Transportation agencies and most notably State Departments of Transportation (State DOTs) sponsor various research projects to enhance the state of transportation in a wide range of impact areas, such as safety, environmental sustainability, and congestion reduction. Determining the value of transportation research projects is a critical step towards promoting high value research projects and assuring that research funds are not misappropriated. Although a variety of methods and measures have been proposed to determine the value of transportation research, there has not been a study to synthesize these methods and measures and exemplify their actual applications under various impact areas. The overall objective of this paper is to synthesize existing methods and measures for determining the value of transportation research. Through data gathering and analysis, it is found out that most State DOTs (84%) that responded to the survey have future plans to quantify the value of research projects. However, the lack of knowledge about existing methods and measures is a significant barrier for assessing the benefits of research projects across various benefit areas. The results of content analysis conducted on the documents that represent the state of practice in determining the value of research showed that, regardless of the difference in benefit areas, all the managers of transportation research agencies strive to answer 2 critical questions when it comes to determine the value of research: what method and what measure could be used to determine the value of research? This research determines how these critical questions are answered in the current state of practice. The results were presented to research program managers of transportation agencies for validation. These subject matter experts rated the results highly useful to their current practices. The major contribution of this paper is to identify and exemplify various methods and measures that have been successfully used for determining the value of transportation research in a variety of impact areas.

Keywords: Value of Research, Transportation, Methods, Measures.

Introduction

Transportation agencies and most notably State Departments of Transportation (State DOTs) sponsor various transportation research projects to improve transportation system features, such as safety, environmental sustainability, and congestion reduction. The 2015 actual U.S. federal budget for research and development in transportation was $1,363 million (NSF 2017). The 2016 preliminary and 2017 proposed U.S. federal budgets for research and development in transportation are $1,369 million and 1,735 million, respectively (NSF 2017). Transportation research projects are aimed at fostering innovation in different areas, such as safety, environmental sustainability, and congestion reduction. Determining the value of transportation research projects is a critical step to effectively promote high value research projects and to assure that funds are not misappropriated. Despite the great importance of determining the value of transportation research projects, transportation agencies do not always follow a systematic approach to quantify the value of their research projects. Determining the value of transportation

research projects has been challenging for transportation agencies because a variety of different methods and measures have been proposed to determine the value of research across various benefit areas. However, there has not been a single study to synthesize these existing methods and measures and provide examples on how the existing methods and measures have been used to determine value of research.

Various methods have been proposed by researchers for determining the value of transportation research. Cost/benefit evaluation method is found to be the most common approach proposed for determining value of research (Anderson 2010; Worel *et al*. 2008; Ellis *et al*. 2003; Tavakoli and Collyard 1991; Ardis 1988). Methods other than cost/benefit analysis, such as multi-objective analysis technique (Tavakoli and Collyard 1991) and matrix approach (Concas *et al*. 2002) have also been proposed for determining the value of transportation research. The proposed methods have not been systematically utilized by transportation agencies to determine the value of their research projects for a variety of reasons, such as complexity of the methods (i.e., the implementation of the methods is not intuitive), lack of awareness about the alternative methods, absence of implementation history, and data scarcity for implementation.

In addition to the need to select proper methods, appropriate measures are required to quantify the benefits of research. Krugler *et al*. (2006) recognized this need in a study sponsored by the National Cooperative Highway Research Program (NCHRP), and proposed a list of research-related performance measures. The results showed that State DOTs have not widely adopted the proposed research-related performance measures for a variety of reasons. The top reasons for low adoption are practical challenges that make the proposed measures not suitable for determining the value of research in some projects, and lack of awareness about the measures. Several transportation agencies, such as California Department of Transportation (Caltrans), prefer to create their own research-related performance measures that are uniquely customized to capture the specific needs of these agencies. These reasons highlight the importance of identifying existing methods and measures that have actually been used for determining the value of transportation research under various impact areas to enhance awareness about the state of practice.

Recently, transportation agencies have published documents to highlight high value research projects. For example, the Value of Research Task Force of the American Association of State Highway and Transportation Officials (AASHTO) Research Advisory Committee (RAC) compiles high value research projects from across the nation. The annual compilations of high value research projects, titled “Research Impacts: Better - Cheaper – Faster,” are available from 2009 to present. Transportation Research Board (TRB) also publishes documents titled “Research Pays Off.” These TRB documents are prepared to address the need to continually demonstrate the benefits of research in order to enable decision makers to understand the potential for long-term rewards and properly assess the value of research. Although these documents provide excellent examples for determining value of research, there is not a single study to synthesize these examples and provide a holistic view.

Transportation research projects can have impact on various areas. According to the literature (TRB Research Pays off 2015; MAP-21 2012; Ellis *et al*. 2003; Tavakoli and Collyard 1991), transportation research projects provide benefits in several impact areas, including safety,

environmental sustainability, management and policy, infrastructure condition, traffic and congestion reduction, quality of life, freight movement and economic vitality, customer satisfaction, system reliability, engineering design improvement, increased service life, improved productivity and work efficiency, reduced user cost, reduced administrative costs, reduced construction, operations and maintenance (O&M) cost, and materials and pavements. There is a research need to identify the existing methods and measures for demonstrating the true value of research projects in these impact areas. The overall objective of this paper is to synthesize existing methods and measures for determining the value of transportation research in various areas of research impact. To achieve this objective, the following research methodology is utilized.

Methodology

The research methodology consists of the following steps:

1. Conducting a nationwide survey of research project managers in several transportation agencies.
2. Performing follow-up interviews with the selected subject matter experts in determining the value of transportation research projects.
3. Analyzing the content of the documents recommended by the research managers for representing the state of practice in transportation research valuation.
4. Validating the results. The survey was distributed among representatives from 50 State DOTs, the District of Columbia, the Federal Highway Administration (FHWA), and the Transportation Research Board (TRB) via email. The survey findings were analyzed and presented in the following sections.

The results of this research were presented to the members of the Southeast Transportation Consortium (STC) for validation during the annual summer meeting of the consortium. The twelve members of this consortium collectively offer a broad range of talent and expertise in managing several research programs in transportation agencies in the Southeast of the United States.

Results

The survey was distributed among representatives from 50 State DOTs, the District of Columbia, the Federal Highway Administration (FHWA), and the Transportation Research Board (TRB) via email. Representatives from 20 State DOTs (Alaska, California, Colorado, Florida, Georgia, Illinois, Iowa, Louisiana, Maine, Maryland, Minnesota, Mississippi, Montana, North Carolina, Ohio, Pennsylvania, South Carolina, Texas, Utah, and West Virginia DOTs), FHWA, and TRB replied to the survey. The response rate was approximately 40%. This participation rate compares favorably with similar data collection efforts (Hamilton 2009; Nulty 2008).

Table 1 summarizes the main statements expressed by survey respondents. The results show that most respondents (80%) have not conducted any study regarding the value of research. Although

most respondents (84%) have future/present plans to quantify the value of research projects, the lack of knowledge about existing methods and measures is a significant barrier for assessing the benefits of research projects across various benefit areas. The respondents commented that collection and distribution of good evaluation examples are extremely helpful. This result confirms our initial research motivation that identifying the existing methods and measures is critically important for determining the value of research.

Table 1

Summary of the main statements expressed by respondents to the survey

Expressions	Percentage of Respondents
Tried to determine the benefits and the values of the research projects	68%
Used implementation plans to evaluate the benefits of the research projects	12%
Tried to use RPM (Research Performance Measures) for evaluating and documenting the benefits of their research projects	16%
Believed that RPM was a valuable tool	12%
Believed that RPM was not a valuable tool	4%
Believed in potential applicability and utilization of the proposed RPM metrics	76%
Believed in the lack of applicability of the RPM metrics	20%
Noted that they have future plans to quantify research benefits	84%
Showed interest in using RPM as the future plan	24%
Not conducted any study regarding the value of research	80%

The documents representing state of practice in determining the value of transportation research were collected by following up with the individuals who replied to the survey. Members of the American Association of State Highway and Transportation Officials (AASHTO) Research Advisory Committee (RAC) were also contacted via email to provide documents that represent the state of best practice in determining the value of research in several areas that a transportation research project can have an impact on. A total of 42 documents were provided to the research team following the completion of the survey. The collected documents show best examples of valuation of DOT research projects in different areas of impact. These documents were reviewed and their contents were analyzed. The results of content analysis showed that regardless of the difference in the benefit areas, all the managers of transportation research agencies answer two common critical questions when it comes to determine value of research. These two critical questions are:

- What method could be used to determine the value of research?
- What measure could be used to determine the value of research?

Content analysis helped us identify and analyze the methods and measures used in these documents to articulate the value of research. The following sections present the results of content analysis and show how the transportation agencies and researchers answer these two common critical questions. Table 2 presents these 42 research projects.

Table 2

Examples of determining value of research

ID	Project Title	Sponsor
1	An Evaluation of the Benefits of the Alabama Service and Assistance Patrol	Alabama DOT
2	Systems Engineering Guidebook by DOT	California DOT
3	Mobile Work Zone Barrier	California DOT
4	A Study of Bus Propulsion Technologies Applicable in Connecticut and Demonstration and Evaluation of Hybrid Diesel-Electric Transit	Connecticut DOT
5	Rural Road Low Cost Safety Improvements	FHWA
6	Evaluation of Pollution Levels Due to the Use of Consumer Fertilizers under Florida Conditions	Florida DOT
7	Operational and Safety Impacts of Restriping Inside Lanes of Urbane multilane Curbed Roadways to 11 Feet or Less to Create Wider Outside Curb Lanes for Bicyclists	Florida DOT
8	Development and Evaluation of Devices Designed to Minimize Deer-vehicle Collisions (Phase II)	Georgia DOT
9	Assessment of the Impact of Future External Factors on Road Revenues	Georgia DOT
10	Improving Safety in High-Speed Work Zones: A Super 70 Study	Indiana DOT
11	Winter Operations Geographic Positioning Systems and Automatic Vehicle Location	Iowa DOT
12	Calibration of Resistance Factors Needed in the LRFD Design of Driven Piles and Drilled Shafts	Louisiana DOT
13	Evaluation of Ternary Cementitous Combinations	Louisiana DOT
14	Development and Performance Assessment of an FRP Strengthened Balsa-Wood Bridge Deck for Accelerated Construction	Louisiana DOT
15	Evaluation of Surface Resistivity Measurements as an Alternative to the Rapid Chloride Permeability Test for Quality Assurance and Acceptance	Louisiana DOT
16	Accelerated Loading Evaluation of Subbase Layers in Pavement Performance	Louisiana DOT
17	Evaluation of Surface Resistivity Measurements as an Alternative to the Rapid Chloride Permeability Test for Quality Assurance and Acceptance	Louisiana DOT
18	Mechanistic Flexible Pavement Overlay Design Program	Louisiana DOT
19	Cost Effective Prevention of Reflective Cracking of Composite Pavement	Louisiana DOT
20	Implementation of Rolling Wheel Deflectometer (RWD) in PMS and Pavement Preservation	Louisiana DOT
21	A Sensor Network System for the Health Monitoring of the Parkview Bridge Deck	Michigan DOT
22	Economic benefits resulting from road research performed at MnROAD	Minnesota DOT
23	MsDOT Implementation Plan for GPS Technology in Planning, Design, and Construction Delivery	Mississippi DOT
24	Evaluation of an Adaptive Traffic Signal System: Route 291 in Lee's Summit, Missouri	Missouri DOT
25	Diverging Diamond Interchange Performance Evaluation (I-44 & Route 13) and Diverging Diamond Lessons Learned document	Missouri DOT
26	Evaluation of Life Expectancy of LED Traffic Signals and Development of a Replacement Schedule	Missouri DOT
27	Placement of Detection Loops on High Speed Approaches to Traffic Signals	North Carolina DOT
28	Freeway Ramp Management Strategies	Pennsylvania DOT
29	Use of Fine Graded Asphalt Mixes Project 0-6615	Texas DOT
30	Development of an Advanced Overlay Design System Incorporating Both Rutting and Reflection Cracking Requirements	Texas DOT
31	Retrofitting Culverts and Fish Passage-Phase II	Utah DOT
32	Examination of an implemented asphalt permeability specification	Virginia DOT
33	Analysis of Full-Depth Reclamation Trial Sections in Virginia	Virginia DOT
34	Investigation of the use of tear-off shingles in asphalt concrete	Virginia DOT
35	Recycling of Salt-Contaminated Storm Water Runoff for Brine Production	Virginia DOT

36	An assessment of the Virginia Department of Transportation's Animal Carcass Disposal Practices and Guidance for the Selection of Alternative Carcass-Management Options	Virginia DOT
37	Geotechnical Data Management at the Virginia Department of Transportation	Virginia DOT
38	Performance of Virginia's Warm-Mix Asphalt Trials	Virginia DOT
39	Field Comparison of the Installation and Cost of Placement of Epoxy-Coated and MMFX 2 Steel Deck Reinforcement: Establishing a Baseline for Future Deck Monitoring	Virginia DOT
40	Bituminous Surface Treatment Protocol	Washington DOT
41	Development and Application of Safety Performance Functions for Illinois	Illinois DOT
42	Development of Procedures for Determining the Axial Capacity of Drilled Shafts Founded in Illinois Shale	Illinois DOT

Identified Methods to Determine Value of Research

Several methods were identified for determining the value of research (Figure 1). These methods were identified through content analysis of the documents provided to the research team as examples for quantifying research benefits. Methods for determining the value of transportation research are explained and exemplified here:

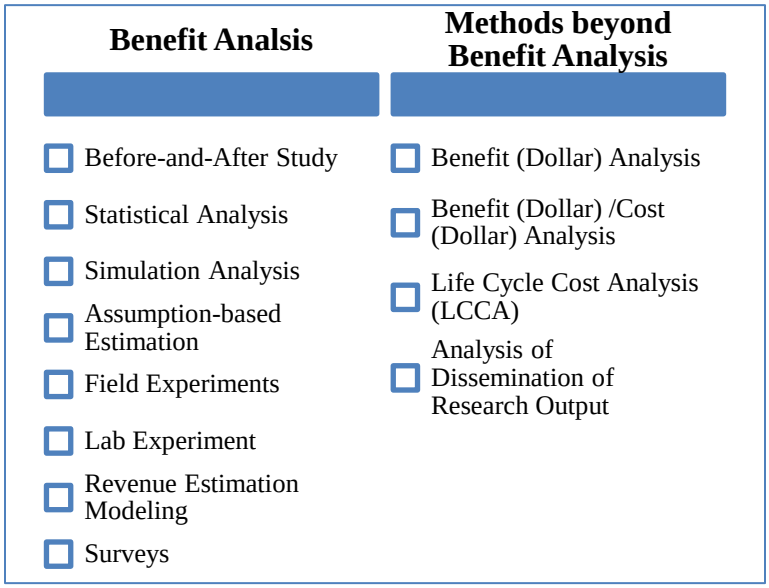

Figure 1: Identified Methods to Determine Value of Research

Benefit Analysis

Benefit analysis is a systematic approach for calculating the value of transportation research projects by determining the improvement in one or several areas. Benefit analysis uses this improvement as the basis to determine the value of research in transportation. For example, safety research projects aim to improve safety-related features of transportation systems, such as reduction in fatalities or accidents. Benefit analysis can be conducted using one of the following approaches within a specific area: before-and-after study, statistical analysis, simulation analysis, assumption-based estimation, experiments, lab experiments, revenue estimation modeling, and surveys.

Before-and-After Study

Before-and-after study has been used to compare conditions of transportation systems before and after a project is implemented to present the benefits of the research project sponsored by a transportation agency. The following examples show how this method has been used in various impact areas:

Safety. For instance, before-and-after study was used to determine safety benefits in the research project entitled "Improving Safety in High-Speed Work Zones: A Super 70 Study." Super 70 was a construction project in 2007 on a heavily traveled interstate I-70 in the central area of Indianapolis. Indiana DOT applied several solutions including traffic management and enforcement countermeasures during the nine-month of construction to enhance safety. Indiana DOT sponsored this research project to determine the value of safety improvement. The overall change in safety in the work zone impact area was estimated using before-and-after study. The before-and-after study was conducted to estimate the safety change in terms of number of crashes on other roads in the I-70 work zone area before and after the work zone onset. Another example using before-and-after study to determine safety benefits is the research project entitled "Diverging Diamond Interchange Performance Evaluation (I-44 & Route 13) and Diverging Diamond Lessons Learned document." Missouri DOT sponsored this project to conduct before-and-after analysis to compare pre-construction and post-construction crash conditions. This comparison enabled the Missouri DOT to evaluate the safety performance of the diverging diamond interchange.

Environmental Sustainability. For example, before and after study was used in the research project entitled "Evaluation of an Adaptive Traffic Signal System." Missouri DOT sponsored this project to determine variations in vehicle emissions (HC, CO, and NOx) on the Route 291. Results showed a decrease of 50 percent in vehicle emissions through using traffic signal system.

Traffic and Congestion Reduction. For instance, in the research project entitled "Evaluation of an Adaptive Traffic Signal System," before-and-after study was used to compare operational measures, such as travel time in morning off-peak and noon-peak period and change in average speed, recorded before the implementation of the system to the same measures recorded one month and five months after the implementation.

Statistical Analysis

Statistical analysis refers to methods, such as regression analysis, that provides a quantitative approach for the objective analysis of benefits based on historical data. The following examples show how this method has been used in various impact areas:

Safety. For example, in the Indiana Super 70 research project, logistic regression was used to estimate the impacts of individual safety countermeasures on the number of crashes.

Engineering Design Improvement. For example, the research project entitled "Calibration of Resistance Factors Needed in the LRFD Design of Driven Piles and Drilled Shafts" used statistical reliability analyses to calibrate the resistance factors for different design methods of

axially loaded driven piles and drilled shafts needed in the LRFD design methodology. Researchers collected and evaluated drift shaft tests and used the statistical reliability analyses to calibrate the resistance factors of the different design methods. The results of this research showed that that local resistance factors were about 10 percent higher than those recommended by AASHTO.

Increased Service Life. For example, in the research project entitled "Evaluation of Life Expectancy of light-emitting diode (LED) Traffic Signals and Development of a Replacement Schedule," rates of degradation were statistically analyzed using Analysis of Variance (ANOVA). The results showed that useful life of LED traffic signals meets or exceeds useful life warranty expectations.

Simulation Analysis

Simulation analysis is used to mimic the operation of a transportation network or a transportation system over time in order to calculate research benefits. Simulation requires developing proper models that represent key characteristics and behavior of a transportation system. The following examples show how this method has been used in various impact areas:

Safety. For instance, in the Indiana Super 70 research project, statistical models were used to forecast the number of expected crashes under certain traffic, weather, and geometry conditions. A sample of 156,646 30-minute intervals with 132 crashes reflecting the historical geometric, traffic, and weather conditions during the construction of Super 70 project was used to simulate safety effects.

Environmental Sustainability. For instance, mobility measures and emission outputs were calculated using simulation in the research project entitled "An Evaluation of the Benefits of the Alabama Service and Assistance Patrol" that was sponsored by the Alabama DOT.

Traffic and Congestion Reduction. For example, the research project entitled "An Evaluation of the Benefits of the Alabama Service and Assistance Patrol" used traffic simulation to estimate the overall delay in (delayed vehicle-hours). This simulation-based approach demonstrated that the reduction in delay to the traveling public is one of the major benefits of the Alabama Service and Assistance Patrol.

Engineering Design Improvement. For example, the research project entitled "Development of an Advanced Overlay Design System Incorporating Both Rutting and Reflection Cracking Requirements" developed a process that integrated the upgraded overlay tester into Texas DOT's current mixture design system and developed an overlay thickness design methodology for Hot Mix Asphalt (HMA). This research project used simulation to test high-performance mixes and optimal thicknesses, particularly in the area of jointed flexible concrete pavements where joints must be repaired prior to placing any overlay. Results showed that it is possible to produce as minimum as 5 percent reduction in the use of asphalt mixes per year due to the improved performance of the overlays.

Assumption-Based Estimation

Assumption-based Estimation refers to the calculation of benefits through assumption-based estimations for key improvement features. The sources of assumptions can be experience, engineering judgment, and the literature. The following examples show how this method has been used in various impact areas:

Safety. For example, crash reduction rates (for the time period after the project is implemented) were drawn from the literature to estimate safety benefits in the project entitled "An Evaluation of the Benefits of the Alabama Service and Assistance Patrol."

Environmental Sustainability. For example, emission rates were drawn from the literature to estimate environmental sustainability benefits in the project entitled "A Study of Bus Propulsion Technologies Applicable in Connecticut and Demonstration and Evaluation of Hybrid Diesel-Electric Transit."

Improved Productivity and Work Efficiency. For example, in the project entitled "Geotechnical Data Management at the Virginia Department of Transportation," it was assumed that on average, the use of this technology would cut in half the time required to gather and process borehole data, resulting in approximately 16 person-hours of savings.

System Reliability. For example, in the project entitled "A Study of Bus Propulsion Technologies Applicable in Connecticut and Demonstration and Evaluation of Hybrid Diesel-Electric Transit," reliability of buses (after the project is implemented) was drawn from the literature and used to estimate reliability benefits.

Field Experiments

Field Experiments refer to experiments that examine the impact of research in the real world. The following examples show how this method has been used in various impact areas:

Safety. For example, in the project entitled "Development and Evaluation of Devices Designed to Minimize Deer-vehicle Collisions (Phase II)," field experiments were conducted to assess the behavioral responses of captive white-tailed deer to visual and physical barriers. These barriers were designed to minimize deer-vehicle collisions. In this research sponsored by the Georgia DOT, the impacts of exclusion fencing on free-ranging deer movement were also found.

Environmental Sustainability. For example, in the project entitled "Evaluation of Life Expectancy of LED Traffic Signals and Development of a Replacement Schedule," field experiments were conducted to assess energy savings of LEDs. Field experiments were also utilized to assess the effect of the manufacturer, indicator type, color, and directional view on the degradation of LED traffic signals. This study, sponsored by the Missouri DOT, helped develop a replacement plan for the LEDs.
Improved Productivity and Work Efficiency. For example, in the project entitled "Development and Performance Assessment of an FRP Strengthened Balsa-Wood Bridge Deck for Accelerated

Construction," field experiments demonstrated that Fiber Reinforced Polymers (FRP) can accelerate the deck installation in half a day, which is faster than current practice.

Traffic and Congestion Reduction. For instance, the research project entitled "Mobile Work Zone Barrier" used field experiments to determine the impact of research on traffic and congestion reduction. The maintenance crew currently using the barrier found that it has eliminated approximately 15% of the lane closures previously required to perform necessary maintenance.

Customer Satisfaction. For instance, the research project entitled "An Evaluation of the Benefits of the Alabama Service and Assistance Patrol" used field data to evaluate services provided for customers. The program provided 17,090 assists from July 1, 2004 through June 30, 2005. This amount is equivalent to an average of approximately 66 assists per weekday.

Increased Service Life. For example, in the project entitled "Cost Effective Prevention of Reflective Cracking of Composite Pavement," field experiments were used to compare different reflective cracking control treatments by evaluating the performance, constructability, and cost-effectiveness of pavements built with these treatments across the state of Louisiana. The Louisiana DOT sponsored this project to assess the performance of 50 different sites that were constructed with various treatments for evaluation periods ranging from 4 to 18 years. The results of this study indicated that saw and seal, and chip seal as a crack relief interlayer showed the most promising results in terms of performance and economic worthiness among various treatments.

Lab Experiments

Lab Experiments is used to assess impacts of transportation research projects on various areas under controlled conditions. The following examples show how this method has been used for quantifying the benefits in various impact areas:

Environmental Sustainability. For example, 46 lab tests were conducted at the University of Central Florida to examine how the amount of phosphorus can be reduced (the phosphorus is undesirable adjacent to bodies of water) in the research project entitled "Evaluation of Pollution Levels Due to the Use of Consumer Fertilizers under Florida Conditions."

Increased Service Life. For example, in the research project entitled "Accelerated Loading Evaluation of Subbase Layers in Pavement Performance," lab experiments were used to evaluate service life of subbase layers. The research results showed that clays with lime and silt combined with cement would create stronger foundations for pavement structure as compared to the raw natural soil. The stronger foundations eliminate the need for reconstruction of bases and pavement and result in longer service life.

Revenue Estimation Modeling

Revenue Estimation Modeling refers to modeling efforts that enable objective analysis of revenue benefits based on historical data. The following example shows how this method has been used for determining research value in the area of management and policy:

Management and Policy. For example, in the research project entitled "Assessment of the Impact of Future External Factors on Road Revenues," a revenue forecasting model was developed to evaluate the implications of changes in several factors that have been shown to impact overall levels of transportation revenue. The model was developed as a "revenue estimation toolbox" to quickly evaluate how different scenarios could influence future fuel tax revenue in Georgia. This model was used to evaluate the reduction in the department's revenues from electric and hybrid vehicles entering the fleet.

Surveys

Surveys refer to methods that are used to collect information from a random sample of a certain population. The following example shows how this method has been used for determining value of research in the area of customer satisfaction:

Customer Satisfaction. For example, in the research project entitled "Diverging Diamond Interchange Performance Evaluation (I-44 & Route 13) and Diverging Diamond Lessons Learned document," survey was used to collect public perception about the project. Missouri DOT sponsored this project to collect the public perceptions from general public, pedestrians, bikers, and driver of larger vehicles, such as truck drivers. The survey results showed that more than 80% of respondents expressed that traffic flow had improved and traffic delay had decreased. 87% of respondents expressed that crash was more likely to occur within a standard diamond when compared to a Diverging Diamond Interchange (DDI). About 80% of respondents expressed that larger vehicles and pedestrian/bike movements through the DDI were better or similar to a standard diamond interchange. More than 90% of respondents expressed good understanding on how the interchange operated with the current design of islands, signing, signals, and pavement markings.

Methods beyond Benefit Analysis

Benefit (Dollar) Analysis

Benefit (Dollar) analysis goes beyond benefit analysis by presenting the value of transportation research in dollar values. The following examples show how this method has been used for determining research value in different impact areas:

Safety. Reduction of fatalities, crashes, and injuries (three common measures of safety improvement) are often calculated in dollar terms. For instance, the expected change in the number of crashes was estimated in the FHWA research project entitled "Rural Road Low Cost Safety Improvements." The estimated crash costs were then applied to the expected change in crashes to estimate the annual dollar savings resulted from the improvements. Crash costs typically vary by States but can be estimated from the FHWA crash cost guide when State-specific crash cost data are not available (Council *et al*. 2005).

Environmental Sustainability. For example, it was shown in the research project entitled "Evaluation of Life Expectancy of LED Traffic Signals and Development of a Replacement Schedule" that an annual energy saving of $120.75 can be realized if one unit of LED is

installed. A 10-year life span and an average electric cost of $0.1/kWh were applied in this analysis.

Improved Productivity and Work Efficiency. For example, in the research project entitled "Geotechnical Data Management at the Virginia Department of Transportation," it was conservatively estimated that the labor-cost savings would be approximately $600 for each average small- to mid-size bridge project. The Virginia DOT had been approving an average of 102 bridges per year for construction for 15 years. Therefore, the potential cost savings were estimated to be in the order of $160,000 per year.

Traffic and Congestion Reduction. For example, in the research project entitled "Mobile Work Zone Barrier," it was estimated that the number of avoided lane closures equated to a potential annual savings of $115,464,000 in public user road costs due to reduced travel delay.

Reduced Construction, Operation, and Maintenance Costs. For example, in the research project entitled "Evaluation of Ternary Cementitious Combinations," it was shown that cement mixtures containing up to 70 percent fly ash and slag exhibited concrete test results that were comparable (or better) than those obtained from control mixtures containing no supplemental cementitious materials. This research indicated potential material cost savings around $25,000 per lane-mile when replacing 70 percent Portland cement with fly ash and slag.

Engineering Design Improvement. For example, the research project entitled "Development and Evaluation of Devices Designed to Minimize Deer-vehicle Collisions (Phase II)" found that the overall cost of the outrigger design installation was 20% less than the standard 2.4 woven-wire design installation ($3,200/mile).

Increased Service Life. For example, in the research project entitled "Cost Effective Prevention of Reflective Cracking of Composite Pavement," benefit (Dollar) analysis revealed that saw and seal was cost-effective in comparison with regular Hot Mix Asphalt (HMA) overlays in 80 percent of sections under study. This analysis also showed that chip seal was cost-effective in comparison with regular HMA overlays in 75 percent of sections under study. Cost data for the high strain reflective crack relief interlayer and HMA overlays were obtained from actual bid items for each project.

Benefit (Dollar)/Cost (Dollar) Analysis

Benefit (Dollar)/Cost (Dollar) analysis (B/C analysis) goes beyond benefit analysis and calculates and compares benefits and costs of research projects in terms of dollar values. The following examples show how this method has been used for determining benefits in various impact areas:

Safety. For example, benefit (Dollar)/cost (Dollar) analysis was utilized in the North Carolina research project entitled "Placement of Detection Loops on High Speed Approaches to Traffic Signals" to evaluate cost effectiveness of alternatives to assess various systems. An estimated 10 percent reduction of crashes was assumed to be achieved due to the installation of the technologies. Crash data for years 2006, 2007, and 2008 were collected from the North Carolina

DOT. The average number of crashes was used for calculating benefits. The equivalent unit crash cost was drawn for each county from the North Carolina DOT Traffic Engineering and Safety Systems branch website. This cost was considered as the project benefit in terms of dollars and was compared with the cost of installation of various systems, such as Detector-Control System (D-CS) and NQ4 system.

Improved Productivity and Work Efficiency. For example, the research project entitled "Winter Operations GPS/AVL" assessed the expected benefits and costs of an integrated (Geographic Positioning System and Automatic Vehicle Location (GPS/AVL) system. The benefits of the Winter Operations GPS/AVL system were calculated in terms of reducing paperwork costs and operating costs. Both initial and annual operating and maintenance costs were also calculated in dollar values. The ratio of benefits to costs was used as an indicator for determining the value of this research project.

Traffic and Congestion Reduction. For instance, the research project entitled "Placement of Detection Loops on High Speed Approaches to Traffic Signals" found that well-placed detectors and a carefully chosen signal timing strategy reduced the likelihood that vehicles would be caught in dilemma zones at the onset of yellow. The research project calculated dollar values of both benefits (reduction in delay) and system costs. It was found that the Detector-Control System (D-CS) system produced benefit-cost ratios significantly greater than 1.0.

Reduced Construction, Operation, and Maintenance Costs. For instance, the research project entitled "Winter Operations Geographic Positioning Systems and Automatic Vehicle Location" studied the benefits and expected costs of an integrated Geographic Positioning System and Automatic Vehicle Location (GPS/AVL) system. The research project calculated dollar values of both benefits in terms of reduced material costs, reduced labor costs, reduced equipment costs, and reduced paperwork, and compared the benefits against the system costs. It was found that the system produced benefit-cost ratio of 17.3.

Customer Satisfaction. For instance, the research project entitled "An Evaluation of the Benefits of the Alabama Service and Assistance Patrol" studied the benefits and expected costs of the Alabama Service and Assistance Patrol. Estimation drawn from the literature (GDOT 2006; Hawkins 1993) was used as the value of customer service per assist. Based on these studies, a range of values from $30 to $60 per assist was used, with the midpoint of $45 assumed to be the most likely value. When applied to 17,090 assists recorded by the Alabama Service and Assistance Patrol (A.S.A.P.) during the study year, the low-end estimate for the economic value of customer service benefits became $512,700, the high-end estimate was $1,025,400, and the most likely value was $769,050. Number of assists and program costs were provided by "Third Division office of the Alabama Department of Transportation." The recorded cost of providing these services was $592,243 from July 1, 2004 through June 30, 2005. The cost information, provided by the Third Division office of Alabama DOT, included (a) capital costs, such as new equipment; and (b) operations and maintenance costs, such as personnel salaries and associated benefits.

Reduced Administrative Costs. For instance, the research project entitled "Winter Operations Geographic Positioning Systems and Automatic Vehicle Location" studied the benefits and

expected costs of an integrated GPS/AVL system. The research project calculated dollar values of both reduction in administrative costs (realized through reduced paperwork) and system costs.

Life Cycle Cost Analysis (LCCA)

Life Cycle Cost Analysis evaluates costs in various areas of research associated with all the stages of a transportation system's lifecycle. The following examples show how this method has been used for various impact areas:

Reduced Construction, Operation, and Maintenance Costs. For example, the project entitled "Analysis of Full-Depth Reclamation Trial Sections in Virginia" compared a traditional pavement rehabilitation program (based on partial- and full-depth mill and replacement) with one that incorporated full-depth reclamation (FDR) using a LCCA approach. The present costs of the traditional pavement rehabilitation approach were multiplied by the total area of the potential FDR sites. The cost over a 50-year life cycle was calculated as $60.95 million. It was estimated that the Virginia DOT could save approximately $10 million over a 50-year period by implementing an FDR program for those flexible pavements identified on the primary network.

Increased Service Life. For example, the project entitled "Accelerated Loading Evaluation of Subbase Layers in Pavement Performance" used LCCA to determine value of research. The research objective of this project was to explore and develop a methodology to build reliable subgrade layers stabilized with cementitious agents at various field moisture contents. The research results showed that clays with lime and silts combined with cement would create stronger foundations for pavement structure as compared to the raw natural soil. LCCA results showed that subbase in place of a lime-treated working table layer would create 37 percent annualized cost savings for low-volume and 31 percent cost savings for high volume pavement structures in Louisiana using 12-in. cement stabilized soil.

Analysis of Dissemination of research output

Analysis of dissemination of research outputs refers to the investigation of penetration of research outputs, such as guidelines, tools, and software pieces, in the research and practice communities. The following examples show how this method has been used for various impact areas:

Intelligent Transportation Systems. For example, in the project entitled "Systems Engineering Guidebook," the dissemination of the research output into the research and practice communities was measured. The statistics on acquisition during the first 2 years (2007 to 2009) of operation were used to attest to the usefulness of the System Engineering Guide Book (SEGB).

Identified Measures to Determine Value of Research

Table 3 summarizes the identified measures used for determining the value of research. These measures were identified through content analysis of the documents recommended by transportation research managers as best examples for quantifying research benefits.
Various measures were identified for determining the value of research in different areas of benefits. The identified measures were critically analyzed and then, categorized for each area of benefit. After analyzing the identified categories of measures, it is concluded that there is a common structure that can be adopted to place the identified measures (i.e., metrics). The following two categories provide a common structure for classifying the identified research measures across different areas of benefits:

- Benefit Measures: For instance, "An Evaluation of the Benefits of the Alabama Service and Assistance Patrol" research project used the reduction in occurrence rate of secondary crashes to determine the value of safety research (Turochy *et al*. 2009).
- Cost saving measures: For instance, "An Evaluation of the Benefits of the Alabama Service and Assistance Patrol" research project used dollar benefits of the reduction in occurrence rate of secondary crashes to determining the value of safety research (Turochy *et al*. 2009).

The identified measures were organized based on areas of benefit that the transportation research has made an impact on, such as Safety. In fact, impact area has been an important factor for selecting the measures for determining the value of research. For example, only cost-saving measures have been used to determine the value of research in two areas of benefits (i.e., reduced construction, operations and maintenance (O&M) costs and reduced administrative cost) due to the inherent characteristics of these areas. In contrary, the value of research in the area of system reliability has not been determined using the cost-saving measures.

Table 3

Summary of the identified measures for different areas of benefits

Areas of Benefit	Benefit Measures	Cost Saving Measures
Safety	- Number of crashes (fatal, injury, or property damage) saved. - Lateral separation between the motor vehicle and bicyclist. - Motor vehicle outside through lane usage. - Motor vehicle speeds before, during and after passing bicyclist. - Number of stops reduction.	- Dollar benefits of reduction in crashes.
Environmental Sustainability	- Reduction in emission outputs (e.g., HC, CO2, CO, NO_x). - Fuel consumption saving. - Energy savings due to use of LEDs. - Amount of reuse of the storm water runoffs.	- Reduction in emission outputs (HC, CO, CO2, and NOx) and anticipated fines. - Disposal cost savings by recycling of salt-contaminated storm water. - Cost savings due to use of LEDs.
Improved Productivity and Work Efficiency	- Reduction in time of set-up and breakdown of a lane closure. - Reduction in percentage of lane closures. - Time saving. - Productivity improvement.	- Reduction in percentage of lane closures. - Reduced material costs. - Reduced labor costs. - Reduced equipment costs, and paperwork. - Cost savings due to time savings.
Traffic and Congestion Reduction	- Reduction in percentage of lane closures. - Travel time reduction and average annual traffic. - Reduction in navigation errors and light violation. - Reduction in intersection delay and number of stops.	- Motorists savings due to reduction in delays, reduction in percentage of lane closures, reduction in intersection delay and number of stops
Reduced Construction, O&M Costs		- Energy savings and reduction in amount of annual fertilizer. - Reduced material costs, labor costs, equipment costs, and paperwork costs. - Disposal savings by recycling of salt-contaminated storm water, reuse of the storm water runoff. - Pavement rehabilitation savings. - Construction and rehabilitation cost savings.
Management and Policy	- Revenue level	
Customer Satisfaction	- Number of services provided to motorists - Enhanced public perceptions.	
System Reliability	- Comparative reliability in percentage. - Average mean distance between failures.	
Engineering Design Improvement	- Reduction in daily deer movements in response to fencing. - Increased flexibility. - Reduction in the use of asphalt mixes.	
Increased Service Life	- Increased Service Life.	- Cost of pavement rehabilitation.
Reduced Admin. Cost		- Reduced paperwork savings.

Validation

Several subject matter experts, who were research program managers of transportation agencies, rated the results highly useful. Minor recommendations were offered to enhance the quality of the research. For instance, several documents were introduced to the research team for consideration as potential sources for identifying methods and measures that can be utilized in finding the value of research projects.

Subject matter experts highlighted flexibility as the key for determining the value of research. The results of this research do not recommend enforcing a single method for determining the value of research. In contrary, it assists managers of research programs in a transportation agency to determine the value of research by providing them with exemplary valuation cases identified by subject matter experts in research programs from other agencies. In addition to flexibility, the subject matter experts and survey respondents provided other valuable comments that highlight the importance of this research and provide a roadmap for any future attempt to develop guideline to determine value of research:

- There is not a formal guideline for assessing benefits of research reports.
- Evaluation methodology for determining value of research should be simple.
- Developing training programs for researchers and DOT personnel is vital.
- Communication of research benefits is important.
- Data scarcity for evaluation of research benefits is a significant challenge.

Conclusion

The results of the survey showed 80% of respondents have not conducted any study regarding the value of research. Although most responding State DOTs (84%) have future/present plans to quantify the value of research projects, the lack of knowledge about existing methods and measures is a significant barrier for assessing the benefits of research projects across various benefit areas. The respondents commented that collection and distribution of good evaluation examples are extremely helpful. Recommended by the survey respondents, a total of 42 documents were analyzed as best examples for determining the value of research. The collected documents were in the form of valuation of DOT research projects that were identified by subject matter experts. These exemplary documents were reviewed and their contents were analyzed. The results of content analysis showed that regardless of all the differences in the benefit areas, all the managers of transportation research agencies answer two common critical questions about the value quantification methods and measures when it comes to determine value of research. This research shows how research program managers in transportation agencies answer these two critical questions. The results were presented to subject matter experts for validation. These subject matter experts rated the results highly useful to their practices as research program managers of transportation agencies.

Several methods (i.e., benefit analysis, benefit dollar analysis, benefit dollar / cost dollar analysis, life cycle cost analysis, analysis of dissemination of research output) have been utilized by transportation agencies to determine the value of research under various identified impact

areas, such as safety, environmental sustainability, productivity and work efficiency, traffic and congestion reduction, and reduced construction, operations and maintenance costs. Benefit analysis has typically been the most frequently used method to determine the value of research projects. Benefit analysis method can be further broken down to the following approaches within a specific area: before-and-after study, statistical analysis, simulation analysis, assumption-based estimation, experiments, lab experiments, revenue estimation modeling, and surveys. Various measures were also identified for determining value of research in different areas of benefits. These measures were categorized for each area of benefit. The major contribution of this paper is to identify and exemplify various methods and measures that have been successfully used for determining value of transportation research in a variety of impact areas.

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Major Delay Factors for Construction Projects in Ghana

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A literature research was conducted and identified ten studies reporting major delay factors for construction projects in Ghana. All these studies are based on self-administered questionnaire survey of views and perception of project participants. Over forty construction delay factors were reported in the literature, and have identified as one of the major construction delay factors by one out of the ten studies on Ghana. A thorough review of these ten studies was undertaken to identify major delay factors for construction projects in Ghana. With respect to the major construction delay factors identified, remedial measures to improve the schedule performance of construction projects in Ghana are presented.

Keywords: Delay factors, Ghana, Construction performance.

Introduction

Schedule performance is one of the most important criteria in assessing construction project success. In order to improve construction project performance through scheduling, it is important to identify the major construction delay factors is the first step in understanding the major factors affecting schedule performance. Second, appropriate management measures can be implemented to address issues related to the major construction delay factors to achieve good schedule performance. The problem with delays in construction projects has been identified as a global phenomenon. This is evident from the large number of studies of more than 208 studies to identify major construction delay factors for 55 countries/administrations reported in the literature published in English. The type of contract in most of the studies reported is traditional and not design-build.

Out of the 208 studies on construction delays reported, only 20 studies that are based on an analysis of the construction delays of actual projects. The other studies use questionnaire surveys, mostly self-administered, of the perceptions and views of owners, contractors and consultants, and a small number of studies reply on interviews or panel discussions of owners, contractors and consultants. A self-administered survey questionnaire is sent to contractors, consultants and owners (including civil servants in charge of construction projects). The questionnaire is developed based on either construction delay factors reported in the literature or by open-ended interviews with selected panels of contractors, consultants and owners. The major construction delay factors are established by statistical analysis of the survey data.

Previous studies on Ghana by Edmonds and Miles (1984), Ofori (1984) reported some of the construction delay factors such as delay in payments of contractors for work done, lack of credit facilities for firms, poor communication and unreliable material supply. In their procurement of audit of Ghana, the World Bank (2003), Westring (1997) and Crown Agents (1998) have continuously reported documentary evidence of contracts taking very lengthy periods to reach

financial closure and also, often subjected to unnecessary delays, poor coordination and communication structures, fiscal constraints and extensive systems of controls and land ownership disputes. There are ten studies, carried out after 2003, to identify major delay factors for construction projects in Ghana reported in the literature. All these studies are based on self-administered questionnaire surveys of views and perception of project participants. Almost all of the forty construction delay factors reported in the literature have been identified as one of the major construction delay factors by one of the ten studies on Ghana. Ghana is not a large country in its physical size and the wide diversity of major construction delay factors identified may be compromised. This has created confusion among the practitioners of the construction industry in devising appropriate measures to improve schedule performance of construction projects. This seems to a major problem and this state of affairs may not provide the most accurate data. In this study, a thorough review of these ten studies is undertaken to identify the top major construction delay factors for construction projects in Ghana to clarify the confusion.

The methodology for the present study is to count the number of each major construction delay factors that have been identified by the ten studies. The top major construction delay factors are those identified by the most number of studies. The major construction delay factors should be factors identified by the most number of respondents in the ten studies on Ghana. Identification of major delay factors for construction projects in Ghana is useful not just for the construction industry in Ghana but also other developing countries. As in many other developing countries, government is the major construction client in Ghana and the market for major projects tends to be dominated by foreign contractors because of deficiencies with the indigenous construction capacity. Bribery and corruption are common used practices for both contractors and consultants in Ghana. Ghana is representative of other developing countries in Africa, Asia and South America. Therefore, major construction delay factors may be relevant to other developing countries in the world.

Major Construction Delay Factors in Ghana

The major construction factors are summarized in Appendix 1 under five categories, namely all project participants related factor, owner related factors, contractor related factors, consultant-related factors and other factors. Each construction delay factor is placed in the category linked to the party which can exert the most influence, though may not be totally, on the effect of that factor. The ‘other factors’ category is for delay factors that are beyond the control of the project participants.

One of the major difficulties in summarizing various construction delay factors identified by various studies is the lack of standardization of the construction delay factors. The following reclassifications are made:

- Chileshe and Yirenkyi-Fianko (2011): “Inflation” and “price fluctuation” are combined and reclassified as “rise in prices of materials,” “Financial failure” is reclassified as “economic conditions,” “Quality and performance control” is reclassified as “rework due to mistakes in construction/construction defects,” “Change of government” is reclassified as “political situation.” “Change of government policy” is reclassified as “government regulations and

permit approval." "Organization and co-ordination" is reclassified as "poor site management and supervision."

- Ahadzie (2011): "Low morale and motivation of craftsmen" identified by is reclassified as "low productivity level of labors." "Over reliance on casual labor" is reclassified as "unqualified workforce/low skilled labor."
- Amoah et al. (2011): "Access to finance" identified by is reclassified as "financing by contractor," "Government policies" is reclassified as "government regulations and permit approval," "Interest rate" is reclassified as "economic conditions," "Ability to delegate responsibility" and "availability of training proprietors and technicians" are combined and reclassified as "lack of technical professionals/incompetent project team," "Professionals engaged" is reclassified as "incompetent or inexperienced staff," "Execution of other projects" is reclassified as "poor site management and supervision."

Construction delay factor "client satisfaction" identified by Amoah et al. (2011) is not included in Appendix 1 because it has never been identified as a construction delay factor in any of the 208 studies in the literature. Construction delay factors such as "owner interference", "slow decisions from owner", "mistakes and discrepancies in design documents by consultant", "delay in inspection and approval of works, approval of shop drawings, materials, and documents submitted by contractor", "late issuance of instructions, information or drawings/incomplete drawings/inadequate information/delay in revising design documents and approving works or materials/delays in design work", "inclement weather", "lack of community buy-in/environmental impact/civil disturbances, youth unrest, militancy and communal crises", "delays by utility agencies/relocation/inaccurate as-built utility drawings" and "natural disaster/acts of God" are common among the major construction delay factors for other developing Asian, African and Middle Eastern counties are found not to be significant by the ten studies.

Perceptions and views may not be correct because they are not based on facts that have been critically reviewed and validated by an independent party. The construction delay factors in studies based on actual projects were assessed and identified by the authors based on past records of construction projects. The construction delays identified were the assessment of the supervising staff and the interpretation of the authors. The accuracy of findings of studies based on self-administered questionnaire surveys hinges on the quality of the survey data. It is obvious that the concern to the quality of the survey data in questionnaire survey studies varies. The number of years of working experience of respondents is crucial because respondents' views and perceptions are formed based on their working experience. According to Kog and Loh (2012), views and perceptions of the survey respondents are affected by the duration of working experience of respondents. Views and perceptions of respondents with less than 15 years are found to be not consistent with respondents with more than 15 years. This seems reasonable considering that the construction period for a reasonably sized project will be around 3 years. A respondent with 15 years working experience will have completed a number of projects equivalent to about 5 reasonably sized construction projects that enable a broader and more incisive understanding of the construction delay factors affecting the construction projects. On the other hand, a respondent with less than 6 years of experience will only have completed one project. Some of the construction delay factors identified are unique to the project only and not typical for the construction industry. This is evidenced from the fact that the major delay factors

identified by these studies are not among the major delay factors identified by the present study. Therefore, validity and reliability of major construction delays for each study reported must take into account the profile of working experience of respondents. Of the ten studies of Ghana using self-administered questionnaire survey, no information on the profile of working experience of respondents was reported in Fugar and Agyakwah-Baah (2010), Frimpong et al. (2003), Danso and Antwi (2012), Buertey et al. (2013), and Chileshe and Yirenkyi-Fianko (2011). This shows a lack of appreciation of the importance of working experience to the quality of the survey data and the validity and reliability of the major construction delay factors identified. There are four out of the nine studies using questionnaire survey that provide information of the profile of working experience of respondents. Out of the 31 respondents of Amoatey et al. (2014), there were 8 respondents (25.8%) with more than 15 years working experience. In Asiedu and Alfen (2016), 6 out of 44 respondents, i.e. 13.6%, have more than 20 years working experience. When the minimum working experience is reduced to 10 years, the respective proportions are: 55/184 (30%) in Amoah (2011), 13/31 (41.9%) in Amoatey et al. (2014) and 12/44 (27.3%) in Asiedu and Alfen (2016). In Afram et al. (2015), 18 out of the 38 respondents, i.e. 51.4%, who were consultants, have 11 to 15 years of working experience. Also, there is no information given for the 58 respondents who were builders and 42/79 (53.2%) of owners claimed that they were "fairly experienced with building construction." The low proportion of "experienced" respondents common in these studies, show a lack of appreciation of the importance of working experience to the quality of the survey data and the reliability of the major construction delay factors identified. Despite the above criticisms, the studies summarized in Appendix 1 are not without values. The major construction delay factors identified by combining the findings of the ten studies for Ghana are more credible because of the larger number of respondents.

The number of times each major delay factor were identified by these studies summarized in Appendix 1 are calculated. The top eight construction delay factors most cited in the ten studies for Ghana are summarized in Appendix 2. It is noted that the top construction delay factor was identified by 80% of the ten studies and the eight construction delay factors were identified by 30% of the ten studies. This amply illustrates the wide diversity of the views and perceptions of the respondents of the ten studies. This can be explained by the low proportion of respondents with more than 15 years working experience of the ten studies. The wide diversity of the views and perceptions of the respondents reinforces the importance of a consistency check of the survey data before they are used for further analysis pointed out in the earlier discussion.

Asiedu and Alfen (2016) identified "contractor selection methods (negotiation, lowest bidder)" as a major construction delay factor responsible for delays of construction projects in Ghana. Buertey et al. (2013) identified "owner interference" as a major construction delay factor. Afram et al. (2015) identified "owner's lack of experience/incompetent project team" and "late release of site/land acquisition problems" as major construction delay factors. Danso and Antwi (2012) identified "unrealistic/optimistic deadline set by client" and "poor site coordination" as major construction delay factors. Chileshe and Yirenkyi-Fianko (2011) identified "subcontractor problems" and "shortage of labor" as major construction delay factors. Ahadzie (2011) identified "low productivity level of labors" and "low level of mechanization" as major construction delay factors. Fugar and Agyakwah-Baah (2010) identified "corruption" as a major construction delay factor. However, none of these factors was identified by other studies as a major construction delay factor. This shows that the views and perceptions with respect to construction delays

among the respondents are very diverse as a result of the low proportion of “experienced” respondents.

Measures to improve schedule performance of construction projects in Nigeria

It must be pointed out that these major delay factors identified by various studies are apparent causes. Some of these apparent causes may not be the root causes of delay as defined by Ellis and Thomas (2002). For example, when utility relocations are an apparent delay factor for a highway project, an in depth investigation by Ellis and Thomas (2002) found that the root cause is insufficient resources. Generally apparent causes are many; root causes are fewer in number. According to Ellis and Thomas (2002), the approach to identify root cause is to trace the process beyond the point of the apparent cause to find the root cause and appropriate corrective action. Root causes of delay may be determined during interviews with practitioners including the contractors. Sometimes, the root cause is not identified by any one individual or organization, but rather emerged from repeatedly hearing similar problems and statements. For the same apparent delay factor, the root cause may be different in different countries because of differing economic and political conditions, practices in the construction sector and cultural background.

The major construction delay factors summarized in Appendix 2 can be grouped under three categories, namely owners, contractors and consultants. The construction delay factor under the owner category is ‘finance and payments of completed work by owner’. Financing of the construction private sector projects depends on the financial strength of the owner/developer and the general economic conditions, in particular the real estate sector, of the country. One measure that can be implemented to address this issue is to require the owner/developer to submit all the necessary financial documents for an exclusive bank account to be set up strictly for the project only prior to the issuance of the permit to commence construction work for the project. In other words, the owner/developer must secure all the financial arrangements prior to the commencement of the construction project. The purpose is to ensure that the owner/developer possess the financial capability to undertake such a development project. Similar administrative measures may be set up for public sector construction projects. If the funding is from an overseas aid agency, then all the necessary document required for the release of the fund must be expeditiously forwarded to the funding agency so that monthly progress payment to the contractor will not be delayed. The root cause of slow progress payment to the contractor may be attributed to the financial problem encountered by the owner. If financing of the project is no longer a problem with the measure discussed earlier, there is a strong need to professionalize the project management teams of owners so that decisions and progress payment to the contractors can be made within the stipulated period. This is consistent with the findings of Kog et al. (1999) and Chua et al. (1999) that project manager competency is one of the critical success factors in schedule performance. According to Laryea (2010), “there is also almost no penalty for delay and short comings on contracts especially because clients tend to default on their responsibilities.” Owners must be educated to understand and reminded repeatedly that any delays in making decisions and progress payment to contractors may lead to construction delays. The costs of construction delays will definitely be more than any benefits that can be obtained from slow decision making and progress payment to contractors.

The construction delay factors under the contractor category are: “late delivery/shortage of construction materials,” “ineffective planning and scheduling,” “lack of technical professionals/incompetent project team” of contractor, “inadequate contractor experience/incompetence contractor,” “rework due to mistakes in construction/construction defects” and “poor site management and supervision.” The non-compensable construction delay factors such as “late delivery/shortage of construction materials,” “ineffective planning and scheduling,” “rework due to mistakes in construction/construction defects” and “poor site management and supervision” identified by the present study are strong evidences that there is a need to professionalize contractors in Ghana. One of the crucial steps is for contractors to employ technical professionals so that a competent project team will be involved in the project. The aim is to improve their planning and scheduling (including the ordering and delivery of construction materials and procurement of equipment), site management and supervision, and site coordination of the project. Most of the local contractors are a family business and they are very reluctant to trust technical professionals outside the family. More importantly, they feared that the overheads of the contractor’s company will be increased resulting inevitably in higher tender prices. This may lead to failure in securing any project in the cut-throat “destructive” competition in tender. Fortunately, as each generation because are educated there will be increasingly a changing trend towards professionalizing the project team. The younger contractors recognize that the benefit of a professional project team outweighs its costs. Despite the existence of the classification system for contractors in Ghana, the schedule performance of contractors needs to be improved further judging from the findings of the present study. Annual review of the classification system of contractors is needed. The contractor’s classification system has to be tightened by including feedbacks from owners and consultants on the schedule performance of construction projects for the last 5 years when assessing the appropriate class of the contractor during the annual review in addition to the current criteria. This requirement is only for higher classes of contractors. Contractors with inadequate appropriate experience will not be awarded the tender for any construction projects if the contractor classification is administered correctly.

The construction delay factor under the consultant category is “substandard contract/incompetent or inexperienced staff.” This suggests that consultants working on construction projects in Ghana have to achieve much higher standards by attending training courses run by reputable universities and professional institutions. Another measure to address this issue is to require tie-up with some reputable international consultants for construction projects in Ghana or appointing reputable international consultants to work on construction projects in Ghana.

For all project participants, construction delay factor “communication problems/lack of adequate project coordination” is identified as a major construction delay factor. Most of the delay caused by the above delay factors can be minimized by better communication among the various project participants. A joint review by the design team has to be conducted during the working drawing stage to minimize any discrepancies in the architectural, structural, mechanical, and electrical drawings that may lead to variation orders. Once the building contract commences, changes that affect critical activities must be avoided whenever possible. According to Kog et al. (1999), “frequency of meetings project manager holds with project personnel” is one of the critical success factors for schedule performance. Chua et al. (1999) found that “construction control meetings” is one of the critical success factors for schedule performance. The owners or

architects must convene regular project meetings to be attended by all consultants and contractor to achieve better communication and co-ordination among project participants. This is necessary also to discuss jointly by all project participants to resolve any issue that may arise that requires the issuance of variation order so that the necessity for variation orders can be minimized. The construction delay factors under the "other factors" category are "rise in prices of materials," "economic conditions," "political situations," and "government regulations and permit approval." The various issues identified by the present study depend to a large extent on government governance and policies. All participants in the construction sector must work together to lobby the government to formulate policies that will improve the operating environment for the construction sector in Ghana.

Conclusion

Good schedule performance can only be achieved by identifying the truly major construction delay factors so that appropriate management measures can be implemented to address issues related to the major construction delay factors. A review of ten studies to identify major construction delay factors was performed in the present study. Major construction delay factors for construction projects in Ghana identified by the present study include: "finance and payments of completed work by owner," "late delivery/shortage of construction materials," "ineffective planning and scheduling," "communication problems/lack of adequate project coordination," "inadequate contractor experience/incompetence contractor," "lack of technical professionals/incompetent project team" of contractor, "poor site management and supervision," "financing by contractor," "rework due to mistakes in construction/construction defects," "substandard contract/incompetent or inexperienced staff" of consultants, "rise in prices of materials," "economic conditions," "political situations," and "government regulations and permit approval." Remedial measures to address issues related to the major delay factors include requiring the owner to submit all the necessary financial documents for an exclusive bank account to be set up strictly for the construction project only. The current contractor classification system must be tightened by including the contractor's schedule performance of past years during the annual review. There is a strong need to professionalize the project team of owners and contractors. Consultants working on construction projects in Ghana must achieve much higher standards in their professional works. The construction delay can be further minimized by improving communication in timely review meetings for owners and all consultants and regular project meetings for owner, consultants and contractors. The practical implication for the construction industry in Ghana is the level of improvement in the schedule performance of construction projects will depend on the extent the various remedial measures have been implemented rigorously.

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Appendix 1

Major Delay Factors for Construction Projects in Ghana

Table Legend:

S = Study is based on a survey of perception of owners, contractors and consultants.
P = Study is based on actual construction projects.
I = Open ended interviews.
A = Building, road, water and sewer etc. projects.
B = Building projects.
C = Civil engineering infrastructural projects such as highway, water and sewer projects.
G = Ground water work projects.
O = Oil and gas projects.
? = Number of respondents not stated in the reference.
@ = Unable to check

References:

1 = Fugar and Agyakwah-Baah (2010).
2 = Frimpong et al. (2003).
3 = Amoatey et al. (2014).
4 = Danso and Antwi (2012).
5 = Asiedu and Alfen (2016).
6 = Buertey et al. (2013).
7 = Afram et al. (2015).
8 = Chileshe and Yirenkyi-Fianko (2011).
9 = Amoah et al. (2011).
10 = Ahadzie (2011).

Reference	1	2	3	4	5	6	7	8	9	10
Methodology of study	S	S	S	S	S	S	S	S	S	@
Number of respondents in the questionnaire survey/projects	130	72	31	67	132	109	172	103	184	@
Type of construction projects studied	B	G	B	C	A	A	B	A	A	B
All project participants related factor										
Communication problems/ lack of adequate project coordination			X	X		X			X	
Owner-related factors										
Finance and payments of completed work by owner		X	X	X	X	X		X	X	X
Variation orders/changes of scope by owner during construction				X						X
Contractor selection methods (negotiation, lowest bidder)					X					
Owner interference						X				
Owner's lack of experience/incompetent project team							X			
Excessive bureaucracy in project-owner organization			X							X
Late release of site/land acquisition problems							X			
Unrealistic/optimistic deadline set by client				X						
Contractor-related factors										
Inadequate contractor experience/incompetence contractor			X			X		X		
Lack of technical professionals/incompetent project team		X		X		X			X	
Ineffective planning and scheduling	X	X				X	X			
Inaccurate estimating of construction materials quantities/price							X			X
Poor site management and supervision	X	X				X	X	X	X	X
Poor site coordination				X						

Late delivery/shortage of construction materials or fuel	X	X		X				X	X	
Financing by contractor	X	X	X		X				X	X
Subcontractor problems							X			
Rework due to mistakes in construction/construction defects				X		X		X		
Low productivity level of labors										X
Shortage of labor								X		
Unqualified workforce/low skilled labor							X			X
Labor disputes/Strikes						X				
Low level of mechanization										X
Consultants-related factors										
Inadequate site investigation/unforeseen subsurface conditions			X			X				
Lack of clarity in project scope						X				
Lack of constructability reviews in design				X			X			
Substandard contract/incompetent or inexperienced staff								X	X	X
Other factors										
Rise in prices of materials			X				X	X		
Economic conditions			X					X	X	
Political situations			X		X			X		
Corruption	X									
Government regulations and permit approval							X	X	X	

Appendix 2

Top Eight Construction Delay Factors for Construction Projects in Ghana

Rank	Construction delay factor	Identified in Studies	
		Number	Proportion (%)
1	Finance and payments of completed work by owner	8	80
2	Poor site management and supervision	7	70
3	Financing by contractor	6	60
4	Late delivery/shortage of construction materials	5	50
5	Communication problems/ lack of adequate project coordination	4	40
5	Lack of technical professionals/incompetent project team of contractor	4	40
5	Ineffective planning and scheduling	4	40
8	Inadequate contractor experience/incompetence contractor	3	30
8	Rework due to mistakes in construction/construction defects	3	30
8	Substandard contract/incompetent or inexperienced staff of consultants	3	30
8	Rise in prices of materials	3	30
8	Economic conditions	3	30
8	Political situations	3	30
8	Government regulations and permit approval	3	30

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