W117 Journal for the Advancement of

Performance Information and Value

Vol. 10, Issue 1

July 2018

July 2018, *Journal for the Advancement of Performance Information and Value Vol. 10, Issue 1*.

Journal for the Advancement of Performance Information and Value
ISSN 2169-0464 (Online)
ISSN 2169-0472 (CD-ROM)
ISSN 1941-191X (Print)

Edited and reviewed by David G. Krassa
Cover Art designed by Kyle Hartwick

Published and distributed by:

Kashiwagi Solution Model Inc.
2251 N 32nd St #5
Mesa, AZ 85213

For information, please email W117 staff at JournalW117@gmail.com.

Editorial Board

Volume 10, Issue 1

Table of Contents

Letter from the Editor **July 2018**

Fellow Researchers & Visionaries:

Welcome back readers of the CIB W117 journal. These are exciting times. We have transformed the CIB W117 working commission and journal from the traditional university setting, to the private industry setting (see PBSRG.com). It is the only private research platform where the results are openly shared in the industry.

The research and education arena are changing rapidly. Instead of operating in silos (academic papers are only read by academics), W117 is using research test results to change the practices of the private industry, leading to potentially radical changes. By minimizing management, direction, and control in the delivery of services, cost can be decreased by 30% and value and quality is increased to a high level of expertise.

W117 is currently involved with three major research projects:

1) Transformation of the Saudi Arabian design and construction industry by utilizing performance information.
2) Implementation of the Best Value Approach and the transforming of the "Facility Manager and Procurement Manager of the Future."
3) The transformation of government procurement by minimizing thinking and decision making of the purchasing personnel.

The concepts of the "Information Measurement Theory," and the use of transparency are resulting in dominant change in the delivery of services. The research is leading to the automation of traditional management, direction, and control professions. These new paradigms will result in the changing of traditional risk management and project management models into automated models.

The approach of this journal is to simplify to understand complexity, to give less information (when information is increased, confusion is maximized), resulting in the industry minimizing their need "to think" and "make decisions." Therefore, the industry hasn't utilized academic research for the past 30 years. It was too difficult to understand. Instead of talking in a different language, we encourage *simple* and **short** papers that the industry can understand, by observation. It identifies that the academic researchers may not have the characteristics of experts if they cannot simplify information. We cannot totally convince the academic community that experts who know what they are talking about can simplify. As an example, there are a couple of papers in this journal which are more difficult to understand. I encourage the readers to see if they can identify which papers are very difficult to understand.

All papers published in this journal, are immediately sent to ResearchGate.net (an open publishing platform). This arrangement has identified which papers are more important, easier to understand and have more value to the research community and industry. This relationship with Research Gate has increased the reads of the papers from 5,000 to 8,000 (60% increase in reads) in less than 10 months.

We encourage all researchers to:

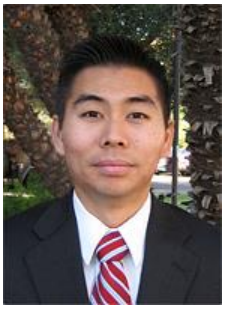
1) Simplify.
2) Use test results to prove value.
3) Publish as quickly as possible.

As a journal editor, we will get the paper "on the street", as soon as possible. We look forward to having more significant papers utilizing performance information which impact industry practice.

Dr. Dean

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

Dean T. Kashiwagi
Editor



Jacob S. Kashiwagi
Secretariat

David G. Krassa
Publication Coordinator

A Global Study on ICT Project Performance

Isaac Kashiwagi (M.Sc.)
Delft University of Technology
Delft, Netherlands

There is a perception of low performance in the information communications technology (ICT) industry with various differing opinions as to the source of the low performance. As technology becomes more integrated within all aspects of society the need for high performance is critical. This research focuses on understanding project performance in the ICT industry. Through literature research an analysis and compilation was performed with 56 publications related to project performance factors, reported performance statistics, and solutions to improve ICT project performance. The research findings establish a definition of performance, identify the current level of performance within the ICT industry, identify existing solutions to the ICT industry and a prioritized listing of 25 factors of project performance.

Keywords: ICT Industry, performance, performance factors.

Introduction

The information communications technology (ICT) industry has had perceived performance issues for years. Performance issues have been identified as early as in 1968 when in a software engineering conference, the so called "software crisis" was addressed (NATO Science Committee, 1969). The crisis was due to the number of software projects failing to be finished on time, on budget, and which met the correct specifications. At the time, the proposed causes of failure included:

1. Complexity of systems.
2. Suppliers lacked expertise due to a lack of experience.
3. Rushed projects due to pressure of meeting the owner's deadlines.

The only consensus to these problems at that time was that the solution was unknown; however, guidance was given to continue to improve on current techniques and not to work outside the present state of technology.

Since 1969 technology has advanced significantly and the methods and theories to deliver ICT projects with it. Methodologies such as rapid application development, the V-model, spiral model, lean software development, and agile methodology have been refined over the years in addition to the supporting tools and software to address the challenges encountered in delivering ICT projects.

Multiple studies and theories of project performance both in the academic and private industry have continuously developed common factors related to project performance. An example of this can be seen as early as 1975, when Frederick Brooks published The Mythical Man-Month. He

outlined factors and practices of performance that are still recognized today. One of the most known is linked to the factor of poor project planning and coordination of resources coined by the phrase “adding manpower to a late software project makes it later” commonly referred to as Brook’s law.

Even with all these advancements within the ICT industry throughout the years, the “software crisis” may not appear to have been resolved. A landmark study published by the Standish group (1994) reestablished the issue when it identified that 83.8% of ICT projects failed to be completed on time and on budget, and projects that were completed by the largest American companies had only 42% of their original features and functions.

The ICT industry is deeply integrated into all industries from healthcare to construction due to the growing dependencies for technology in day to day activities. The challenge of performance has been seen in all sectors of the ICT industry. The latest report published by the Standish Group (2016) focused on eight of the major sectors and revealed little differential in project success.

Research Questions and Methodology

The purpose of this paper is to clarify and understand project performance in the ICT industry. The research seeks to answer the following research questions:

1. How can project performance be defined?
2. What is the performance level of the ICT Industry?
3. What factors are related to ICT performance?
4. What documented solutions have shown to improve performance?

To answer these research questions, an exploratory literature review has been performed to identify, understand and analyze the existing studies of performance in the ICT industry.

Keyword & Database Searching

In the literature research ’ICT Project Performance’ and ‘ICT Project Performance Factors’ were used as the core keywords. The main search engines that were used include Engineering Village, Emerald Insight, Pro Quest and Google Scholar. Engineering Village is comprised of 12 engineering literature and patent databases. In total, the database is comprised of more than 16 million records from over 68 countries and 1,000 publishers. Emerald Insight focuses on research in the practice and management of business. Emerald Insight manages a portfolio of nearly 300 journals, more than 2,500 books and over 450 teaching cases. Pro Quest also focuses on research into business management but extends their database to include dissertations, news, and the latest working papers.

Filtering Criteria

Following the search with the identified keywords, 4 steps or filters were used:

1. The publications had to be available in full text English.
2. Each of the keywords was researched in 400 publications in each of the databases.
3. Publication abstracts were reviewed and filtered based on relation to ICT project performance.
4. Publications were fully reviewed and filtered based on the contribution of either (1) performance metrics (2) an identified list of project performance factors and/or (3) a distinguishable method to improve performance with supporting metrics.

After the review of 1,600 publications' abstracts (see Table 1), 222 were identified to have abstracts related to project performance. After the full publications were carefully read and reviewed, 28 publications were identified to contribute with original project performance information (directly related) and from those 28 publications, 28 more were identified through references used in those papers. In total 56 relevant publications were identified that each presented relevant information to project performance.

Through the 56 studies of ICT project performance it can be observed that the challenges with performance in the ICT industry are not specific to one country. The ICT issues are global. Table 2 gives an overview of the locations where these studies have taken place specifically within the countries of United States, United Kingdom, Finland, The Netherlands, Australia, China, New Zealand, Canada, South Africa, Singapore and Belgium. However, there are some studies which do not disclose the specific countries such as Hoffman (1999) but report surveying over 16,000 companies in 28 countries.

Table 1: Literature Search Results.

Key Word Searches	**ICT Project Performance & ICT Project Performance Factors**		
Source	Searched	Related	Directly
Engineering Village	400	60	10
Emerald	400	45	4
ProQuest	400	70	8
Google Scholar	400	47	6
Total	1600	222	28

Table 2: Demographics of Literature Results, 34 Publications.

Publication Year	#
2016 - 2017	3
2011 - 2015	20
2006-2010	13
2001-2005	13
1969-2000	7

Location	#
General	28
Specific Location(s)	28
Asia	3
Europe	15
Americas	16
Australia	2
Africa	2

Analysis & Findings

From the 56 publications related to ICT project performance the following information was collected:

1. 22 publications that outlined a definition of performance summarized in 7 common factors.
2. 25 publications reporting ICT performance metrics to find the practitioners perception of performance in the ICT industry.
3. 19 publications with identified lists of factors of project performance (success/failure) analyzed to create 25 general factors of project performance.
4. 22 publications pertaining to an identified method to improve performance which are supported by performance metrics.

After reviewing the data collected from the 56 publications, an analysis was performed to answer the identified research questions. To answer the first and second research questions (RQ1 and RQ2), an analysis was performed on publications which defined or reported project performance metrics. The third research question (RQ3) was answered by analyzing all publications which identified a list of factors of project success or failure. The fourth research question (RQ4) was answered by analyzing solutions which provided documented performance metrics to support their claims of improved performance.

Defining Project Performance

In the analysis of the 22 publications which defined performance, 7 factors were identified to be used to define performance. The two most common factors include on budget and on time being cited in over 17 out of 22 publications, see Table 3. The lowest cited factors include cancellation, quality, and use, which were all cited in less than 7 of the 22 publications. The factors of client expectations / satisfaction and required features and functions were close with 14 and 11 publications citing respectively.

In setting a definition of performance it is clear that time and cost are crucial factors. However, the remaining factors are less dominantly expressed in the publications. To simplify the

definition other groups have proposed the remaining factors be grouped into the factor of client expectations or satisfaction as the factors of required features and functions, cancellation, quality and end use all seem to be relevant to the user's expectation or satisfaction with the end result (Standish Group, 2016).

As there is no consensus as to the perception of what constitutes performance, a workable definition must be identified. For this research, based on the literature project performance is defined to be: a project implementation with the criteria of being on time, on budget, and meeting client satisfaction.

Table 3: Defining Performance

Defined Performance Factor	**Frequency (out of 22)**	**%**
On budget	20	91%
On time	17	77%
Client expectations / Satisfaction	14	64%
Required features and functions	11	50%
Cancelled prior to completion	7	32%
Quality	4	18%
Delivered and never used	3	14%

Project Performance Metrics

Of the 34 publications related to project performance, 25 publications reported statistics within the ICT industry. Major studies on the performance metrics of the industry over the years include (listed chronologically):

1. The Standish group (1994). The study surveyed 365 respondents with multiple personal interviews. The findings identified that 83.8% of ICT projects failed to be completed on time and on budget, and projects that were completed by the largest American companies had only 42% of their original features and functions.
2. IT-Cortex (2014) Reported four different studies done on ICT project performance. (1) In 1995 the Organizational Aspects of Information Technology (OASIG) UK group sampled 45 experts primarily employed by Universities or consultancies. The interviews resulted in the identification that the success rate of IT projects is estimated at 20 – 30%. (3) In 1998 the Bull Survey performed 203 telephone interviews with IT project managers who took the lead in integrating large systems within organizations in the Times Top 100 and reported that with the IT projects 75% missed deadlines, 55% exceeded budget and 37% were unable to meet project requirements. (4) In 2001, the Robbins-Gioia survey of ERP systems reported that 51% of ERP implementations were viewed as unsuccessful, 46% of the participants noted that while their organization had an ERP system in place, or was implementing a system, they did not feel their organization understood how to use the system to improve the way they conduct business.

3. Hoffman (1999) reported the results from Howard Rubin's annual worldwide IT trends and benchmark report which surveyed more than 16,000 IT professionals at 6,000 companies and in 28 countries. The results reported 85% of IT organizations in the US are failing to meet their organizations strategic business needs.
4. Whittaker (1999) reported a study done in 1997 surveying chief executives of 1,450 public and private sector organizations across Canada in the ICT industry, of which 176 were analyzed. The findings included 87% of failed projects exceeded their initial schedule estimates by 30% more. This compare to 56% of failed projects that exceeded their estimated budget by the same amount, and 45% of failed projects which failed to produce the expected benefits
5. Taylor (2000) analyzed 1,027 projects and interviewed 38 practitioners of the association of project managers and institute of management. The findings revealed that out of the 1,027 projects only 130 or 12.7% were successful.
6. Sauer and Cuthbertson (2003) from Oxford surveyed over 1500 practicing IT project managers and found that 16% of projects end up with an average cost overrun of 18%, schedule overrun of 23% and 7% underachievement of scope / functionality.
7. KPMG (2005) conducted a global IT project management survey of more than 600 companies in 22 countries. Some of the dominant results showed that in the past 12 months 49% of participants experienced at least one project failure. In the same period only 2% of organizations achieved benefits all the time, and 86% of organizations lost up to 25% of target benefits across their entire portfolio.
8. The European Services Strategy Unit (2007) reported 105 outsourced public-sector ICT projects with 57% of contracts which experienced cost overruns with an average cost overrun of 30.5%, average schedule overrun of 33% and 30% of contracts which were terminated or never used.
9. The US Accountability office (2008) identified 413 IT projects--totaling at least $25.2 billion in expenditures for the fiscal year of 2008--as being poorly planned, poorly performing, or both. With just under half being re-baselined at least once.
10. The Genenca group's (2011) survey included 600 U.S. businesses IT executives and practitioners and reported that 75% of respondents admit that their projects are either always or usually doomed right from the start, of which 27% always felt this way (2011).
11. Flyvbjerg and Budzier's (2011) entry for the Harvard Business Review did an analysis of 1,471 IT projects and reported an average cost overrun of 27%, of which 17% had a failure high enough to threaten the company's existence, with an average cost overrun of 200% and schedule overrun of 70%.
12. McKinsey & Company (2012) analyzed over 5,400 projects and reported 50% of IT projects on average are 45% over budget, 7% over time, 56% less value than predicted and 17% of projects end so badly they can threaten the life of the company.
13. The Standish Group (2016) analyzed their database of over 25,000 projects to find that 61% of projects failed to complete on time, on budget with a satisfactory result.

Other performance metrics have been reported without details such as the year the study was conducted, or methodology used to explain the metrics. Although these performance metrics are not as dominant they are important to consider when examining the perception of the industry:

1. 15% of all software development never delivers anything, and has overruns of 100-200% (DeMarco, 1982).
2. There is a 50-80% failure rate of large projects (Dorsey, 2000).
3. An estimate of 5-15% of all large-scale software projects are cancelled in the USA and the total yearly cost of cancellations may be as much as US $75 Billion (Savolainen & Ahonena, 2010).
4. Kappelman et al. (2002) cites two studies: (1) reporting 20% of IT projects are cancelled before completion and less than a third are finished on time and within budget and expected functionality. (2) study reports these numbers to more than double when considering large projects with 10,000 function points.
5. Fenech and De Raffaele (2013) report three different studies: (1) an independent study by McCafferty revealed that 25% of the projects will not succeed in meeting the requirements, amounting to around $63 billion annually spent on such failed initiatives, (2) a global study held by Gartner for 845 ICT companies concluded that 44% of the analyzed projects exceeded budget allocations, 42% failed to be delivered within agreed timeframes and over 42.5% lacked in achieving all expected benefits by the end of the project, (3) Young's study reported that 15-28% of ICT projects in Australia were abandoned prior to implementation, around 30% experienced significant cost overruns sometimes up to 189% and less than 20% had achieved all the established performance objectives.
6. As many as 25% of all software projects are cancelled outright, as many as 80% are over budget, with the average project exceeding its budget by 50%. It is estimated that three-fourths of all large systems are operational failures because they either do not function as specified or are simply not used (Schmidt et al, 2001).
7. Dijk (2009) reports that 34% are successful, 51% does not go according to plan but ultimately does lead to some result and 15% of the projects fail completely.
8. Molokken and Jorgensen (2003) studied 6 different studies to find the performance statistics varying for ICT projects. Cost overrun was reported by four studies with 33%, 33%, 34% and 89%. Projects completed over budget was reported by four studies with 61%, 63%, 70%, and 80%. Projects completed after schedule was reported by three studies with 65%, 80%, 84%.
9. Procaccino et al. (2002) cited two studies: (1) in 1994, 31% of all corporate software development projects resulted in cancellation and (2) a more recent study found that 20% of software projects failed, and that 46% experienced cost and schedule overruns or significantly reduced functionality.

Multiple countries have addressed the issue of ICT project performance on a governmental level including the United Kingdom, the Netherlands, Australia and the United States. The UK government has spent over 16 billion on IT projects in 2009 in a wide range of areas, yet the UK has been described as "a world leader in ineffective IT schemes for government". In 2011 the House of Commons in England appointed a special committee to investigate the state of their government IT performance (Public Administration Committee, 2011). In addition to lessons learned and the identification of the sources of failure, the investigation revealed various high

costing IT initiatives over the last twenty years which ended in failure. (Public Administration Committee, 2011).

In 2012 - 2014 a Netherlands parliamentary inquiry was held to address the poor performance of ICT projects in the Public space (The House of Representatives of the Netherlands, 2014). During the enquiry, it was reported that 1-5 billion Euros are wasted in the Netherlands with ICT projects annually. Recent and notable projects by the media and government inquiry included (The House of Representatives of the Netherlands, 2014):

1. Defense department project (SPEER) cancelled after spending € 418 million.
2. Belastingdienst ETPM project cancelled after spending € 203 million.
3. Police Investigation Suite (PSO) Cancelled in 2005 after spending € 430 million.
4. C2000 emergency police and others implementation costs € 72 million overbudget due to delays.
5. Payroll administration (P-direct) failed tender costs of € 200 million with a potential € 700 million more.
6. EPD Electronic Patient File cancelled after spending € 300 million.

In 2013 – 2014 the Legislative Assembly of the Northern Territory of Australia held a government inquiry that was prompted by ongoing concerns raised by the Auditor-General regarding the management of information and communication technology projects (Legislative Assembly of the Northern Territory, 2014). The chairperson of the committee commented that it was clearly unacceptable to spend over $70 million only to make systems worse. In the inquiry three large government projects were specifically analyzed:

1. The department of infrastructure's attempt to replace their nine legacy systems used to manage the Government's asset management information systems and business processes with an integrated commercial off the shelf product (COTS). The project was budgeted at $14 million and to be completed on April 10th. The project was cancelled in March 2014 where it cost around $70 million.
2. The Power and Water Corporation (PWC) project to replace a suite of old systems which were poorly integrated and no longer supported by the suppliers. The project was budgeted at $15 million and to be completed on March 12th. The project was completed in August 2012 where it cost approximately $51.8 million.
3. The Department of Health's grant management system project was to develop and implement an ICT system to support the management of service agreements with NGOs. The project was budgeted at $684 thousand and to be completed in November 2011. The project was still in progress with an expected budget of $979 thousand and with an expected completion date of June 2014 when the last report was created.

The United States has not held an official government inquiry however from 2011 – 2014 the United States has also experienced similar high failure rate with government IT projects, reportedly spending billions of dollars on projects which are incomplete, cancelled, or nonfunctional. Recent and notable projects include:

1. The USAF's attempt to automate and streamline their logistics operations by consolidating and replacing over 200 separate legacy systems. The project was cancelled after spending $1.1 billion, project incomplete and nonfunctional (Institute for Defense Analysis, 2011; Kanaracus, 2012; United States Senate Permanent Subcommittee on Investigations, 2014).
2. The state of California's attempt to merge 13 separate payroll systems into a single system that served 243,000 employees. The project was cancelled after spending $254 million and had proven to be nonfunctional (Chiang, 2013; Kanaracus, 2013).
3. The Census Bureau's attempt to convert to handheld computers for the 2010 census. The project was cancelled after spending up to $798 million for a nonfunctional product (Nagesh, 2008; US Department of Commerce, 2011).
4. The IRS's continual attempt to update their system from legacy software. Multiple projects have been cancelled with over $4 billion spent (Hershey, 1996; Moseley, 2013; Thompson, 2012).
5. The US Government's online healthcare website, "Obamacare" was originally budgeted for $93 million. Official statements of costs have not been calculated but estimations calculated it to be as high as $634 million (Costello & Mcclaim, 2013; Dinan & Howell, 2014; Vlahos, 2013).
6. The Federal Aviation Association's attempt to consolidate their terminal automation system for an initial $438 million; the cost overrun has been estimated to be $270 million. The project was still ongoing and is nonfunctional according to the last reports of the project (Levin, 2013; Perera, 2013).

The various performance studies and reports performed through surveys, interviews, and case studies use different types of performance statistics, methods to achieve those statistics and values of those performance statistics. It is also unmentioned, in most studies, the ICT sector being measured. Each reported study also defines performance in a different way. Due to these factors, it is unclear and not verifiable to determine a universal performance level of the entire ICT industry. However, from the literature we can conclude that there is a general consensus that, the ICT industry is perceived to have performance issues. The chronology and time period which the performance metrics cover also reveals that the ICT industry has been experiencing these perceived issues with performance for multiple years.

Factors of Project Failure

Of the 56 publications related to ICT project performance, 19 were found to have identified a list of factors of ICT project performance (success/failure). In analyzing these 19 publications, we identified 325 factors that were cited to be linked to ICT project performance (success and failure). We found that although the factors were worded differently, many of the factors were similar. Additionally, for practicality and usability, many factors could be grouped into a larger, broader factor. After fully reviewing all factors there were 25 overall factors that were identified. In Table 4 the factors are prioritized in terms of the number of publications (of the 19) in which

it was cited. Publication frequency was determined as a more accurate prioritization tool as some studies identified lists which were exhaustive in both critical factors and minor. By using publication frequency of factors, the risk of minor factors outweighing critical factors would be minimized. (Al-ahmad et al., 2009; Dorsey, 2000; Emam & Koru, 2008; Geneca, 2011; Henderson, 2006; IT Cortex, 2014; Jiang et al., 1999; Kappelman et al., 2002; Keil, Tiwana & Bush, 2002; Mckinsey, 2012; Michael, 2002; Milis, & Mercken, 2002; Nasir & Sahibuddin, 2011; Sauer & Cuthbertson, 2003; Savolainen & Ahonen, 2010; Standish Group, 1994; Standish Group, 2016; Taylor, 2000; Yeo, 2002).

Table 4: Factors of Project Performance.

#	Project Factors	Publication Frequency (out of 19)	%
1	Project planning / estimation / coordination of resources	16	84%
2	Project team's capability (technical knowledge, resources, and skills)	15	79%
3	Undefined, Unclear, and/or misunderstood project scope (requirements, objectives, and purpose)	14	74%
4	Changing project scope (requirements, objectives, and purpose)	13	68%
5	Support of top management and leadership	13	68%
6	Client involvement	12	63%
7	Project managers capability (technical knowledge, resources, and skills)	10	53%
8	Project alignment with the business objectives, goals, and needs of the organization	10	53%
9	Project management methodology	9	47%
10	Communication between stakeholders	8	42%
11	Capability to manage project scope changes	7	37%
12	Creation of an unrealistic requirement	7	37%
13	Project alignment with the organization's conditions	7	37%
14	Capability to track and understand performance throughout project execution	6	32%
15	New technology, tools, and/or methods	6	32%
16	Support and approval of user / client	6	32%
17	Rapid development of deliverables	3	16%
18	Definition of roles and responsibilities	6	32%
19	Undefined project success criteria	5	26%
20	Multiple interacting parts (suppliers, systems, organizations, departments, community, etc.)	4	21%
21	Conflict between client stakeholders (Departments, organizations, etc.)	4	21%
22	Lack of user education and training	4	21%
23	Project team not given enough control over the project	3	16%
24	Risk management	3	16%
25	Large project size (duration and cost)	3	16%

The 325 factors were then grouped by 6 categories, shown in Table 5. Table 5 shows the average publication frequency of the factors by category. Of the factor categories, capability is the most cited by the publications. Scoping, planning and the buyer – supplier relationship ranked relatively similar in importance. However, although the ICT industry is known to be an industry of changing technology and "mega" projects, technology and size were the least mentioned for publication frequency.

Table 5: Factors of Project Failure.

Factor Category	Average % Publication Frequency
Capability	51%
Scoping	45%
Planning	43%
Buyer – supplier Relationship	42%
Technology	24%
Size	18%

With any of these studies of ICT project performance factors it is important to consider that there is no consensus as to the exact factors. Nasir and Sahibuddin (2011), Wateridge (1995) and Fortune and White (2006), conducted similar studies of ICT project performance factors, all of which concluded that there is no broad consensus among researchers and practitioners in determining project performance factors.

Literature (Nasir and Sahibuddin, 2011; Sauer and Cuthbertson, 2003; Dorsey, 2000) reveal that the project manager (PM) has been a primary focus of the identified factors. This may be due to the perceived role of the PM, defined by the Project Management Institute PMBOK Guide (2017). For example, the PMBOK describes the role of a project manager to be summarized in 10 areas of knowledge include: 1) Integration, 2) Scope, 3) Schedule, 4) Cost, 5) Quality, 6) Resource, 7) Communications, 8) Risk, 9) Procurement, 10) Stakeholder.

Using the definition of the PMBOK (2017), the PMs role can be observed to interact with most of performance factors as summarized in Table 6. Of the 25 factors listed in Table 4, 16 are not specifically cited within these 10 areas. The reason they are not mentioned could be attributed to the factor specifically mentioning the level of capability the project implementer:

1. Factor #2: Project team's capability (technical knowledge, resources and skills).
2. Factor #7: Project manager's capability (technical knowledge, resources and skills).

Or because the factor is dependent on the buyer or predetermined conditions that are not clearly seen as the responsibility of the project manager. These factors are interestingly amongst the lowest cited, 3 of 4 being amongst the least cited.

1. Factor #15: New technology, tools, and/or methods.
2. Factor #22: Lack of user education and training.
3. Factor #23: Project Implementer not given enough control over the project.
4. Factor #25: Large project size (duration and cost).

Table 6: Project Manager Responsibilities and Performance Factors.

#	**Project Management Process Group and Knowledge Areas**	**Performance Factor(s)**
1	Project Integration	5, 8, 9, 13, 18
2	Project Scope	3, 4, 12, 19
3	Project Schedule	1, 11, 14, 17, 20
4	Project Cost	1, 3, 4, 11
5	Project Quality	14
6	Project Resource	1, 18
7	Project Communications	10
8	Project Risk	24
9	Project Procurement	-
10	Project Stakeholder	5, 6, 10, 16, 20, 21

#	**Other Areas**	**Factor**
1	Specific to project implementer's capability	2, 7
2	Determined by buyer or project conditions	15, 22, 23, 25

Nasir and Sahibuddin's study (2011) found that the project manager could control the top 5 critical risks or a project (clear requirements and specifications, clear objectives and goals, realistic schedule, effective project management skills and methodologies, and support from top management). Sauer and Cuthbertson (2003) indicated similar findings with their study's recommendations being to improve on the capability of project managers. Dorsey's (2000) research listed the top three reasons for failure to include: top management support, a sound methodology and a solid technical leadership. Taylor's (2000) results also describe the project manager's role related to these factors including gaining the support and commitment of top management and ensuring clear communication between stakeholders.

The analysis of the overall 25 performance factors listed from the 19 studies (Table 4) in combination with previous research, gives greater insight into the importance of the capability of the project implementer to performance.

ICT Proven Solutions

Of the 56 publications related to project performance, 3 methods were distinguishable with supporting research to show improved performance in the ICT industry. There are many broad approaches that have been suggested to improve performance, such as improving governance of projects or greater goal alignment (The House of Representatives, 2014; Milis and Mercken, 2002), however when in the search for approaches, only approaches which were distinguishable as a standardized method and which had supporting research reflecting improved performance were considered.

The first approach is the Agile project management methodology used by the project implementer (Beedle, et al., 2001). Its success has been attributed to its ability to handle complexity by utilizing the capability of the project implementer in short timeframes called sprints. Cutter Consortium (2008) identify the methodology as a method to deal with the

increasingly complex software and system. The Scrum Alliance (2013) promotes that Agile practices are a key adaptation that organizations are making in the face of heightened business complexity. QSM Associates (2009) identifies that the disruptive factors of complex sourcing have already driven most of organizations towards iterative processes and Agile approaches. VersionOne (2007) survey reported that 67% of respondents agreed that agile improved the reduction of process complexity.

Agile has become mainstream in the ICT sector with as high as 84% of ICT companies practicing agile methodologies and over 5,000 Project Management Institute (PMI) certified practitioners, making it the fastest growing PMI certification (Project Management Institute, 2014; Scrum Alliance, 2013; Serena, 2012; VersionOne, 2013). In comparing this new development methodology to traditional approaches, the Standish group concluded Agile had a success rate (delivered on time, on budget, with required feature and functions) 28% higher compared to the traditional waterfall approach (Standish Group, 2011). Various other industry reports and surveys support the Standish group with claims of improvement in cost, time to market, risk, defects and productivity when switching from traditional methodologies to agile (Cutter Consortium, 2008; QSM Associates, 2013; Scrum Alliance, 2013; Shine Technologies, 2002; VersionOne, 2007).

The second and arguable simplest approach proposed is to make projects smaller. This is a deductive manner that would minimize the project scope in terms of project conditions such as the number of stakeholders, integration between conditions, duration, etc. The assumption is that smaller projects would be, by definition, less complex and would result in better results (Sauer & Cuthbertson, 2003). The Dutch Parliamentary noted during their inquiry that projects are "too large and too complex" (The House of Representatives, 2014), identifying the fact that large projects are significantly more likely to fail than smaller. The Standish group (2013) reports a high level of success with smaller projects compared to large projects with a 66% difference in success rate (Table 7). Success in this situation being determined by delivery on time, on budget, with required features and functions.

Table 7: Large vs. Small Projects.

	Small Projects	**Large Projects**
Success	76%	10%
Fail	4%	38%

***** Small projects are considered <$1 million in labor cost, Large project >$10 million.
Source: Adapted from the CHAOS Report 1995. Boston, MA: The Standish Group International, Inc.

The Standish Group (2011) initially reported the benefits of using the agile project management method over the traditional waterfall approach by comparing the success rate (in terms of on time, on budget, with required features and functions) of 14% to 42% based on their database of performance metrics. However, in a more recent report (Standish Group, 2013) measuring only small projects under one million dollars, the benefit of the project management approach was minimized with a difference of success of 3% (see Table 8). These findings suggest a decrease in project size results in a decrease in the importance of the project management approach or

project implementer's capability. Therefore, with smaller projects, the need for project management capability may be reduced.

Table 8: Large vs. Small Projects Methodology.

	All Projects (2011)		Small Projects (2013)	
	Waterfall	**Agile**	**Waterfall**	**Agile**
Success	14%	42%	49%	46%
Fail	29%	9%	8%	6%

Source: Adapted from the CHAOS Report 2011 and 2013. Boston, MA: The Standish Group International, Inc.

Results of the Giarte Study (2014), that is conducted annually to ICT clients/buyers in the Netherlands, analyzed ICT project size as well. This third-party performance measurement firm conducted an analysis with the ICT performance rating information they had collected for their 2012, 2013 and 2014 annual reports. Giarte compared the client's satisfaction on large and small projects in the ICT infrastructure management domain from both midsize and large providers. From the results the following can be observed (Table 9):

1. Midsize providers in all three years received higher customer satisfaction in their small projects than the large providers for both small and large projects.
2. Large providers for 2012 and 2013 received higher customer satisfaction on their large projects than their smaller projects.
3. In 2014 large providers received higher customer satisfaction on their smaller projects.

The results differ from the Standish Group and Dutch Inquiry's conclusions of ICT project size and ICT performance as it would suggest that project size may have less of an impact than the project implementer. Sauer & Cuthbertson (2003) in analyzing the UK projects noted similar results showing the results of projects regardless of size are similar, differing however, only with projects as they become extremely small or extremely large.

Table 9: Percentage Satisfied Respondents, Infrastructure Management.

	Midsize Providers	Large Providers	
	****Small Deals**	****Small Deals**	***Large Deals**
2012	88%	59%	70%
2013	89%	76%	85%
2014	90%	85%	79%

** Deals considered large are >5 million EUR / year*
***Deals considered midsize are < million EUR / year*
Source: Adapted from the Outsourcing Performance 2014 Report by Giarte.

The third approach is the Best Value Approach (BVA) which was was first conceived through research at Arizona State University (ASU). The BVA is a philosophy and methodology which focuses on utilizing the capability of the project implementer (supplier in most cases) to improve

performance and minimize complexity (Kashiwagi, 2017). A study conducted in 2013 comparing BVA to other traditional processes found a key differentiator to be that the BVA used an expert supplier model (Kashiwagi, 2013). The BVA has been heavily documented to be successful in improving performance including (PBSRG, 2014):

1. Most licensed university developed technology at Arizona State University with 38 licenses issued by the innovation group AZTech at Arizona State University. BVA tests have been conducted in 31 states in the U.S. and five different countries besides the U.S. (Finland, Botswana, Netherlands, Canada, and Malaysia).
2. Documented performance of over 1,700 projects delivering $6 billion (1629 projects, $4B in construction and 89 projects, $2B in non-construction), customer satisfaction of 9.8 (out of 10), 93.5% of projects on time and 96.7% on budget.
3. Research tests show that in procuring of services outside of construction, the observed value is 33% or an increase of revenue or decrease in cost of 33% (Kashiwagi, J., 2013).
4. The results of BVA testing has won the 2012 Dutch Sourcing Award, the Construction Owners of America Association (COAA) Gold Award, the 2005 CoreNet H. Bruce Russell Global Innovators of the Year Award, the 2001 Tech Pono Award for Innovation in the State of Hawaii, along with numerous other awards.

The BVA has been analyzed by outside groups multiple times. However, there were two investigations that performed a thorough study on the impact and effectiveness of the system. These studies all confirmed that the performance claims of the BVA system were accurate:

1. The State of Hawaii Audit (Kashiwagi et al. 2002; State of Hawaii Report 2002 (DIS)).
2. Two Dutch Studies on the Impact of PIPS (Duren & Doree, 2008; Rijt & Santema, 2012).

Specifically in the ICT industry case studies have been documented to show improved performance:

1 The State of Oklahoma COTS-ICT Tax software (Kashiwagi, 2014).
2 ICT Networking for one of the largest Universities in the United States (Rivera, 2014).
3 Port of Rotterdom and a large ICT vendor to (Kashiwagi et al. 2015).
4 Large ICT vendor's sales and marketing group (Kashiwagi et al. 2015).
5 The municipality of Eesmond telephone facilities (Logemann & Kashiwagi, 2017).

All three approaches differ in how to improve performance but all three approaches similarly identified an importance of the project implementor's capability when improving performance.

Conclusion

The focus of this paper was to further investigate the level of performance in the ICT industry by answering the research questions of R1, how can project performance be defined; R2, what is the performance level of the ICT Industry; and R3, what factors are related to ICT performance? In response to R1, project performance was found to be most commonly defined by time, cost and customer satisfaction. Customer satisfaction is a compilation of various related factors such as

cancellation, end use, quality and features and functions. This definition is relevant as it was taken from 22 publications which presented performance metrics or factors in which the definition was applied.

In response to R2, it was found that there have been multiple studies and reported statistics of the ICT industry. The difficulty is that the type, method of collection and value of statistics being reported are varied. With the existing reported statistics, it would not be possible to set a standard level of performance for the ICT industry. However, there is a common consensus of all the metrics and context given that millions of dollars are being lost each year due to performance issues and that the ICT industry is perceived as having performance issues with the need to improve.

In response to R3, 25 general factors of performance were identified that effect project performance, with planning, project team's capability, and an undefined scope as the top three reasons respectively. The factors were further analyzed by 7 categories which revealed capability of the project implementer as one of the most crucial and new technology and project size as the least critical. This was confirmed by previous literature, emphasizing the importance of the project implementer.

In response to R4, 3 solutions were identified with documented performance metrics to support their ability to improve ICT project performance. Among the three included are the agile methodology, making projects smaller, and the Best Value Approach. All three were determined to be different but similar in their focus in improving performance through their focus on the capability of the project implementer.

Reflections

The study attempts to be complete in understanding project performance within the ICT industry, however, there are potential limitations due to the small sample size of publications and key words that were reviewed (1,600 publications and 2 key words). A more exhaustive literature search could have been performed, however as all reported statistics have followed the same trend in terms of performance statistics and factors, this study can be considered a sort of microcosm of the existing performance statistics in the entire ICT industry. The study captures all current well-known performance statistics and can be added as new statistics are discovered.

The ICT industry covers a wide range of services, these services or sectors vary in performance conditions depending on the service. In the studies examined, specific services of the ICT industries were not identified. The author recognizes that all sectors in the ICT industry may not follow the general trend in the ICT industry in terms of the level of performance and performance factors. However, to understand the level of performance without expending resources ourselves to perform all the studies, a literature search was deemed the most effective tool. An acceptable factor with the literature search is to be limited by the content of the studies performed by other researchers.

The method of compiling and comparing performance factors was limited in terms of the consistency and quantity of characteristics. Each list that was used had a different number of

characteristics listed. The author found it more beneficial to minimize the risk of incorrect interpretation and decision making by including all characteristics and using frequency cited in a publication instead of the quantity of characteristics to prioritize the factors.

With the findings of this research the author has identified that the poor performance and causes of failure have been relatively unchanging for many years, even with the constant improvement in existing solutions. The author feels it is necessary to conduct further research in order to reexamine the approach and root causes of the ICT project failure and further the development of research into solutions with regards to the supplier's expertise.

References

Al-ahmad, W., Al-Fagih, K. Khanfar, K., Alsmara, K., Abuleil, S., Abu-Salem, H. (2009) A taxonomy of an IT project failure: root causes. International Management Review, 5 (1), 93-106.

Baccarini, D., Salm, G., & Love, P. E. (2004). Management of risks in information technology projects. Industrial Management & Data Systems, 104(4), 286-295.

Beedle, M., Bennekum, A. V., Cockburn, A., Cunningham, W., Fowler, M., Highsmith, J., et al. (2001). Principles behind the Agile Manifesto. http:// agilemanifesto.org/principles.html.

Budzier, A. & Flyvbergj B. (2011). Why your IT project may be riskier than you think. Business Harvard Review, 89 (9), 601-603.

Chiang, J. (2013) 21st Century Project. California State Controller's Office. http://www.sco.ca.gov/21century.html

Costello, T., Mcclaim, E. (2013, October) Obamacare glitches: Gov't contract for troubled site has swelled; GOP targets Sebelius. NBC News. http://www.nbcnews.com/news/other/obamacare-glitches-govt-contract-troubled-site-has-swelled-gop-targets-f8C11419179

Cutter Consortium. (2008) How agile projects measure up, and what it means to you. Arlington, MA: Mah, M., Lunt, M.

DeMarco, T. (1982). Controlling software projects: Management, measurement & estimation. New York, NY: Yourdon Press.

Dijk, A. J. V. (2009). Success and failure factors in ICT projects: a Dutch perspective (Doctoral dissertation, Middlesex University).

Dinan, S., Howell, T. (2014, April) Price of fixing, upgrading Obamacare website rises to $121 million. Washington Times. http://www.washingtontimes.com/news/2014/apr/29/obamacare-website-fix-will-cost-feds-121-million/?page=all.

Dorsey, P. (2000) Top 10 reasons why systems projects fail. Dulcian Inc.

Duren, J. and Doree, A. (2008) An evaluation of Performance Information Procurement System (PIPS), 3rd international public procurement conference proceedings 28(30) pp 923-946.

El Emam, K., & Koru, A. G. (2008). A replicated survey of IT software project failures. IEEE software, 25(5), 84-90.

European Services Strategy Unit. (2007). Cost overruns, delays and terminations: 105 outsourced public-sector ICT projects (Report No. 3). Duagh, Ireland: Whitfield, D.

Eye4Management. ("Government & ICT ", n.d.) https://owl.english.purdue.edu/owl/resource/560/03/.

Fenech, K., & De Raffaele, C. (2013, June). Overcoming ICT project failures-A practical perspective. In Computer and Information Technology (WCCIT), 2013 World Congress on (pp. 1-6). IEEE.

Fortune J, White D (2006). Framing of Project Critical Success Factors by a Systems Model. Int. J. Proj. Manage., 24(1): 53-65

Geneca. 2011. "Doomed from the Start? Why a Majority of Business and IT Teams Anticipate Their Software Development Projects will Fail. Winter 2010/2011 Industry Survey.

Giarte. (2014) Report Transformers Outsourcing Performance 2014. Amsterdam, Netherlands: n.d.

Government Accountability Office. (2008). OMB and Agencies Need to Improve Planning, Management, and Oversight of Projects Totaling Billions of Dollars. (GAO Publication No. 08-105IT). Washington, D.C.: U.S. Government Printing Office.

Henderson, P. (2006) Why Large Projects Fail. School of Electronics and Computer Science University of Southampton.
Hershey, R. (1996, April) A technology overhaul of I.R.S. is called a fiasco. New York Times. http://www.nytimes.com/1996/04/15/us/a-technological-overhaul-of-irs-is-called-a-fiasco.html
Hoffman, T. (1999). Study: 85% of IT departments fail to meet business needs. Computerworld, 33(41), 24.
Institute for Defense Analysis (2011) Assessment of DoD Enterprise Resource Planning Business Systems. Alexandria, Virginia: Ketrick, P., Bailey, J., Cunningham, M., Odell, L., Douglas, G., Floyd, D., Insolia, A.
IT Cortex, (Online). Available from: http://www.it-cortex.com/Stat_Failure_Rate.htm and http://www.parthenon.uk.com/project-failure-bull.htm (Accessed: 24 August 2016)
Jiang, J. J., Klein, G., Balloun, J. L., & Crampton, S. M. (1999). System analysts' orientations and perceptions of system failure. Information and Software Technology, 41(2), 101-106.
Jones, C. (2006). Social and technical reasons for software project failures. CrossTalk, 19(6), 4-9.
Kanaracus, C. (2012, February) Air Force scraps massive ERP project after racking up $1B in costs. Computer World. http://www.computerworld.com/s/article/9233651/Air_Force_scraps_massive_ERP_project_after_racking_up_1B_in_costs
Kanaracus, C. (2013, February) California ends contract with SAP over troubled IT project. Computer World.http://www.computerworld.com/s/article/9236662/California_ends_contract_with_SAP_over_troubled_IT_project?taxonomyId=214&pageNumber=2.
Kappelman, L., McKeeman, R., Zhang, L. (2009) Early warning signs of IT project failure: the dangerous dozen. The EPD Audit, Control and Security Newsletter, 40 (6), 17-25.
Kashiwagi, D. (2014). 2014 Best Value Standard. Performance Based Studies Research Group. Tempe, Az. Publisher: KSM Inc., 2014.
Kashiwagi, D., Savicky, J & Kashiwagi, A (2002). Analysis of the Performance of 'Best Value' Procurement in the State of Hawaii. ASC Proceedings of the 38th Annual Conference, Virginia Polytechnic Institute and State University – Blacksburg, Virginia, pp. 373-380.
Kashiwagi, I. (2017). A Global Study on ICT Project Performance (or "Manuscript in preparation").
Kashiwagi, I., van Hes, S., Tschi, G. C., & Kashiwagi, D. (2015). The Cause of Collusion in the IT and Construction Industries. Journal for the Advancement of Performance Information & Value, 7(1).
Keil, M., Tiwana, A., & Bush, A. (2002). Reconciling user and project manager perceptions of IT project risk: a Delphi study1. Information Systems Journal, 12(2), 103-119.
KPMG (2005), Global IT Project Management Survey – How committed are you? KPMG
Kruimel (2012, September) Mislukte projecten van de overheid kost ons miljarden per jaar. Plazilla. http://plazilla.com/page/4294999411/mislukte-projecten-van-de-overheid-kost-ons-miljarden-per-jaar.
Legislative Assembly of the Northern Territory. (2014) Management of ICT Projects by Government Agencies. Northern Territory, Australia. National Library of Australia Cataloguing-in-Publication Data
Levin, A. (2013, May) Air-traffic upgrade over budget, facing delays: report. Bloomberg. http://www.bloomberg.com/news/2013-05-31/air-traffic-upgrade-over-budget-facing-delays-report.html
Logemann N. & Kashiwagi, I. (2017). Professionals' Impressions Regarding the Saudi Arabian Procurement and Contracts System. Performance Information and Value, 51.
Mckinsey & Company. (2012). Delivering Large scale IT projects on time, on budget and on value. New York City, NY: Bloch, M., Blumberg S, Laartz, J.
Michael, E., Abela, A., & Beltz, T. (2002). Seven Characteristics of Dysfunctional Software Projects. The Journal of Defense Software Engineering.
Milis, K., & Mercken, R. (2002). Success factors regarding the implementation of ICT investment projects. International Journal of Production Economics, 80(1), 105-117.
Molokken, K., & Jorgensen, M. (2003, September). A review of software surveys on software effort estimation. In Empirical Software Engineering, 2003. ISESE 2003. Proceedings. 2003 International Symposium on (pp. 223-230). IEEE.
Moseley, J. (2013, November) Government computer failures are normal. American Thinker. http://www.americanthinker.com/2013/11/government_computer_failures_are_normal.html
Nagesh, G. (2008, April) Census to scrap handheld computers for 2010 count. Nextgov. http://www.nextgov.com/technology-news/2008/04/census-to-scrap-handheld-computers-for-2010-count/41957/
Nasir, M. H. N., & Sahibuddin, S. (2011). Critical success factors for software projects: A comparative study. Scientific research and essays, 6(10), 2174-2186.

Nato Science Committee. (1969) 1968 Nato Software Engineering Conference. Garmisch, Germany: Editors Naur, P., Randell, B.
PBSRG. (2014). Performance Based Studies Research Group Internal Research Documentation, Arizona State University, Unpublished Raw Data.
Perera, D. (2013, June) TRANCON air traffic control modernization faces prospect of more schedule, cost overruns. Fierce Government IT. http://www.fiercegovernmentit.com/story/tracon-air-traffic-control-modernization-faces-prospect-more-schedule-cost/2013-06-02
Procaccino, J. D., Verner, J. M., Overmyer, S. P., & Darter, M. E. (2002). Case study: factors for early prediction of software development success. Information and software technology, 44(1), 53-62.
Project Management Institute. (2014, May) PMI certification statistics. PMI Today.
Project Management Institute. (2017). A guide to the project management body of knowledge (PMBOK guide). Newtown Square, Pa: Project Management Institute.
Public Administration Committee. (2011). Government and IT— "a recipe for rip-offs": Time for a new approach. Twelfth Report of Session, 12.
QSM Associates. (2009) The agile impact report proven performance metrics from the agile enterprise. McLean, VA: n.d.
Rijt, J., Santema, S. (2013) The Best Value Approach in the Netherlands: a reflection on past, present, and future. Journal for advancement of performance information and value, 4 (2), 147-160.
Ringelestijn, T. V. (2014, June) Mislukt it-project kost Belastingdienst ruim 200 miljoen euro. Web Wereld. http://webwereld.nl/beveiliging/82955-mislukt-it-project-kost-belastingdienst-ruim-200-miljoen-euro
Rivera, A. O. (2014). Impact of a Non-traditional Research Approach (Doctoral dissertation, Arizona State University).
Sauer, C., Cuthbertson, C. (2003) The State of IT Project Management in the UK 2002-2003. Computer Weekly, 2003, London (82-page report).
Savolainen, P., Ahonen, J. (2010) Software engineering projects may fail before they are started: Post-mortem. The journal of systems and software, 83, 2175-2187.
Schmidt, R., Lyytinen, K., Keil, M., Cule, P. (2001) Identifying software project risks: An international Delphi study. Journal of Management Information Systems, 17 (4), 5 -36.
Scrum Alliance. (2013) The state of scrum: benchmarks and guidelines. Orlando, FL: Kim, D.
Shine technologies. (2002) A passion for excellence. Melbourne, VIC: n.d.
Standish Group. (1994). CHAOS Manifesto 1994 Boston, MA: The Standish Group International, Inc.
Standish Group. (2011). CHAOS Manifesto 2011. Boston, MA: The Standish Group International, Inc.
Standish Group. (2013). CHAOS Manifesto 2013. Boston, MA: The Standish Group International, Inc.
Standish Group. (2016). The Winning Hand. The Standish Group International, Inc.
State of Hawaii PIPS Advisory Committee (2002), Report for Senate Concurrent Resolution No. 39 Requesting a Review of the Performance Information Procurement System (PIPS), Honolulu, HI: U.S.Government, Available from: http://Hawaii.gov/dags/rpts/pips.pdf>.
Taylor, A. (2000). IT projects: sink or swim. The computer bulletin, 42(1), 24-26.
The House of Representatives of the Netherlands (2014) Conclusions and recommendations of the Dutch temporary committee on government ICT projects.
Thompson, J. (2012, April) Fixing the IRS. Government Executive. http://www.govexec.com/magazine/features/2012/04/fixing-irs/41637/
United States Senate Permanent Subcommittee on Investigations (2014) The Air Force's Expeditionary Combat Support System (ECSS). Washington, D.C.: Levin, C., McCain, J., Bean, E., Kerner, H., Patout, B., Davis, L., Dean, A., Robertson, M., Henderson, A.
US Department of Commerce. (2011). Census 2010: final report to congress. (Final Report No. OIG-11-030-I). Washington, D.C.: U.S. OIG Office of Audit and Evaluation.
VersionOne. (2007) 2nd annual survey "the state of the agile development. GA: n.d.
VersionOne. (2007) Agile development: results delivered. Alpharetta, GA: n.d.
VersionOne. (2013) 7th annual state of agile versionone agile made easier development survey. Alpharetta, GA: n.d.
Viergever, Nico (2014 March) ICT-projecten komen in de problemen omdat het ICT-projecten zijn. Management Site. http://www.managementsite.nl/43055/ict-internet/ict-projecten-falen-ict-projecten.html
Vlahos, K. (2013, October) Just how much did HealthCare.gov cost? Fox News. http://www.foxnews.com/tech/2013/10/11/just-how-much-does-healthcaregov-cost/
Wateridge J (1995). IT projects: A Basis for Success. Int. J. Proj. Manage., 13(3): 169-172

Whittaker, B. (1999). What went wrong? Unsuccessful information technology projects. Information Management & Computer Security, 7(1), 23-30.
Yeo, K. T. (2002). Critical failure factors in information system projects. International Journal of Project Management, 20(3), 241-246.

Additional Criteria to Maximize the Performance of the Procurement System Delivery Method in Saudi Arabia

Ahmed A. Alofi (PhD)
Taibah University
Madinah, Saudi Arabia
Dean T. Kashiwagi (PhD)
KSM, Inc.
Mesa, AZ, United States
Jacob S. Kashiwagi (PhD)
KSM, Inc.
Mesa, AZ, United States

The current Saudi Arabia (SA) procurement system leads to many losses in money and benefits in projects. The estimated percentage of delayed projects in SA during the past decades is more than 70% of the total projects. A questionnaire has been developed and carefully designed to improve the current SA procurement system. The questionnaire was sent out to 1,396 participants, the SA Council for professional engineers, who work in both private and public sectors. The participants are interested in the SA procurement and contracts system with experience ranging from one to more than twenty-five years in common construction sectors. Most of the participants from both private and public sectors agreed with the survey statements regarding zone price proposals, contractors' evaluation, risks, planning, projects' scope, owners concern and weekly risks reports (WRR). Based on the survey, a model, called SVIE procurement system, has been developed in which the most expert contractor is chosen through four phases: submittals & education, vendor selection, illustration, and execution. The resulting model is easy to implement by SA government and does not require special skills or a background.

Keywords: Saudi Arabia, Procurement, construction delays, government, case study.

Introduction

The Kingdom of SA has had a major change in its construction industry in recent decades. This growth came from the continued economic development of SA (Kacst, 2011). Also, the country has received one of the largest and most important construction industry markets in the Middle East region. This country is going to lead much of the expansion in the region in coming years (World Construction, 2012). It has been discovered that seventy percent (70%) of the total delays in the projects run by the Ministry of Housing and Public Works in SA were delayed (Zain Al-Abedien, 1983). Al-Sultan (1987) has received a similar percentage of project delays and found that seventy percent (70%) of the government projects had time-overrun issues. Al-Ghafly (1995) has done a survey to define the frequency and degree of construction projects delays by collecting data through the projects' parties such as owners, contractors and consultants. The contractors think that around thirty-seven percent (37%) of the projects suffered from delays, and consultants think that eighty-four percent (84%) of the projects had some delays. The time overrun is approximately thirty-nine percent (39%) over the project's time Al-Ghafly (1995).

Assaf and Al-Hejji, (2006) have measured the project's performance in SA. The projects suffer from delays, and the percentage of delays is 10%-30% of the original scheduling time. Al Turkey (2011) conducted a questionnaire surveying around 300 project managers who work at different sectors. The questionnaire objective was to address the implementation issues that are related to

ventures is SA. Some of the results found that eighty percent (80%) of the ventures were subject to overrun costs, and ninety- seven percent (97%) did not follow the original scheduling time. Another study has been conducted to find the reasons that cause delays in projects and identified 63 factors that have impacts on projects and classified them to four different categories based on the source. One of the most important results found were that the most factors affecting a project negatively was from the clients (Albogamy et al., 2012). A study conducted a survey in SA to identify the factors that cause delays on projects and found that the most important factor related to clients is the lack of finance to complete projects, clients' inability to pay contractors as well as payments delays (A. Al-kharashi and M. Skitmore, 2008).

The procurement system is a key factor linked to project performance. Alofi (2015) analyzed the current SA procurement system. The current system consists of three main sections: the public competition, direct and special purchases. Most of the purchases go through the public competition. The existing system awards to the contractor or vendor who has the lowest price among the contenders. The awarded vendor's price should be within market prices and not less than 35% of the current market prices.

Various studies have attempted to improve methods of procurement to address the issue of non-performance. T. Alhazmi and R. McCaffer (2000), in general, have found some difficulties in most of these studies that provide models for procurement systems as the following:

- There are several significant factors in the selection phase that did not consider all procurement systems.
- Owners cannot use some procurement systems because they are difficult to implement
- Some of them require advanced mathematical methods that may hinder the use by the owners.
- Some of the models are primitive in the selection phase and have lack of standards in some options.
- There are few options in the model numbers in the database.

One of the most documented procurement models to deliver high performance is the Performance Information Procurement System (PIPS). In 1994, Dr. Dean Kashiwagi founded PIPS and has been the director of the Performance Based Studies Research Group (PBSRG). The PIPS has been tested by PBSRG's researchers over 1,750 times in 31 states and 7 countries around the world with around 98% of clients' satisfaction. It has been tested with project costs up to $6.3 billion ($2.2 billion in non-construction projects and $4.1 billion in construction projects). The PIPS consist of three phases (Selection, Clarification and Execution) to ensure that the vendors or contractors are qualified to take future projects with success. The concept of PIPS is to reduce direct management and control that have been used by owners over vendors or contractors.

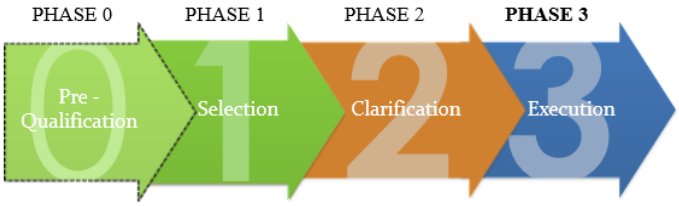


Figure 1: PIPS Phases (Adapted from Kashiwagi, 2014).

Problem

The Saudi procurement system is the one of the most important issues that has negative effects on the construction industry in the Kingdom of SA. The negative effects are a result of the contractors who have been selected through the procurement system who are not qualified (Assaf and Al-Hejji, 2006). A. Al-kharashi and M. Skitmore (2009) conducted a survey through 86 participants to find out the reasons for delay in government projects in SA and found that one of the most important reasons is the lack of qualified personnel. In addition, the biggest problem in the Saudi procurement system is the selection of contractors' basis on lowest price (Albogamy et al., 2012).

Proposal

This paper proposes an overall development of the SA procurement and contracts system to counter the delays and money losses in projects. The method proposes conducting a survey of many professional engineers to get an opinion on the current Saudi procurement system (1,396 participants).

The research paper has several objectives, as follows:

- To conduct a survey of many professional engineers who have an interest with the SA procurement system and licensed under the Saudi council of engineers to develop the current procurement system.
- To add two different effective phases to increase the performance of the current Saudi procurement system.
- Also, this paper has proposed a solution for the issues of delayed projects in SA.

Methodology

- Identify the issues in SA traditional delivery method by surveying proper literature.
- Review PIPS delivery method and the traditional SA procurement system.
- Identify gaps in the traditional SA procurement system and propose additional criteria from PIPS.
- Conduct a survey among professional participants to identify their perception of the additional criteria for the proposed model.
- Conduct an analysis on the data and compare results between both private and government sectors.

Survey & Design

The survey was designed to develop the SA's current procurement system by taking perceptions of large number of participants who are interested with procurement and contracts system in SA from both public and private sectors. This development is through two essential phases, pre-construction and during construction, and the separation between the two phases is contracts signing. The survey contained seven important questions relating SA's current procurement system and PIPS, zone price proposals, contractors' evaluation, risks, planning, projects' scope, owners concerns and weekly risks reports. The model derived from the answers of the questions can be used to radically change the current Saudi procurement system.

The participants were able to answer the questions by using two different options:

1. Yes; No.
2. I Strongly Agree; I Agree; I Strongly Disagree; I Disagree; I Do Not Know.

Distribution

The author contacted the Saudi council of engineers, an official agency in SA which is responsible to license the foreign and Saudi's engineers to practice in the construction industry to send a survey to professional engineers using the agency access. All the engineers who participated in the survey have an interest in the procurement and contracts system in SA. This survey was sent to engineers who work in the private and government sectors, where both sectors follow the instructions of the current procurement and contracts system in SA. The questionnaire was collected through many participants to collect accurate results for their opinions. Out of 12,683 participants who received the survey, 1,396 professional engineers participated in this survey. The number is constituted of 1,151 participants belonging to the private sectors and 245 from the government sectors. In combination, both sectors included 867 engineers, 256 consultants, 121 contractors, 35 owners and 132 architects and 13 academics. All participants had experience between one year to more than twenty-five years in several different areas in the construction industry.

Results

As seen in Figure 1, regarding the contractors' evaluation, approximately ninety-four percent (93.7%) of the participants who work in the private sectors and around ninety-six percent (96.1%) of them who work in government sectors agreed to evaluate the previous contractors' projects before the contract is signed, to ensure their efficiency for next project. Regarding the risks identification, approximately ninety percent (90.1%) of the participants who work in the private sectors consented that identifying risks before a contract is signed would improve project performance. Alofi (2015) found that around eighty-nine percent (88.7%) who work in governmental sectors think that the project performance improvement will require the contractor to identify risks before a contract is signed as seen in Figure 2.

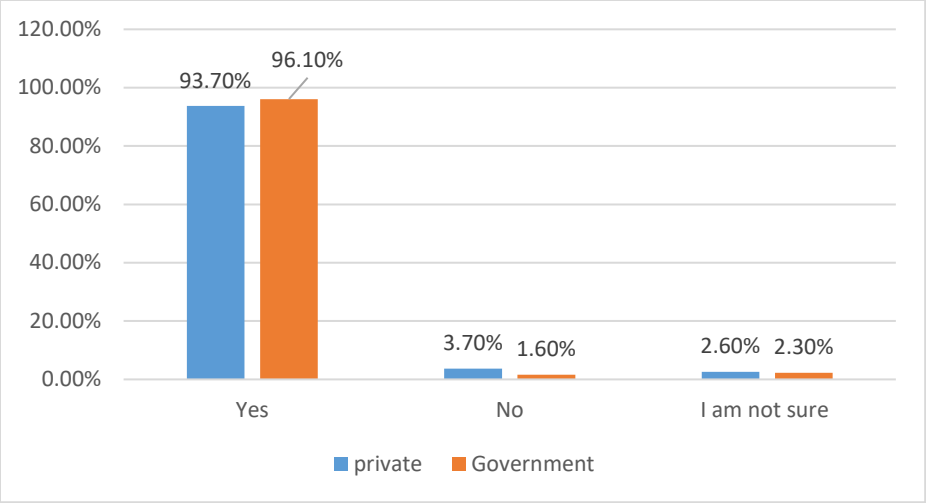


Figure 2: The evaluation of the previous contractors' projects before the contract is signed to ensure efficiency for the next project.

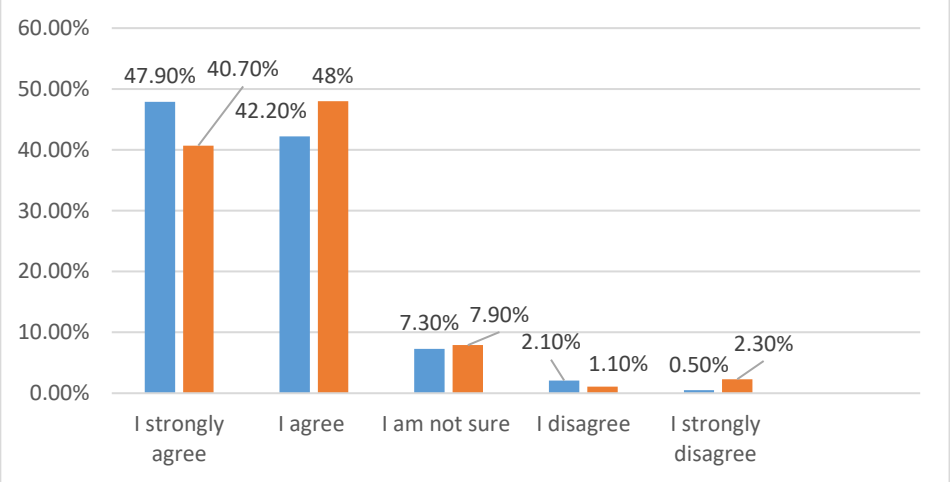


Figure 3: Requiring contractors to identify risks before a contract is signed, would improve project performance.

Figure 3 shows that ninety-six percent (96%) of the participants who work in the private sectors agreed that contractors having plans before a contract is signed improves the performance of the project thus minimizing losses in time and money. Alofi (2015) found that ninety-six percent (96%) from the participants who work in the public sectors agree that before a contract is signed the contractors should have plans to improves the project performance and minimize losses in money and time. Regarding the scope of projects, around ninety-five percent (95%) of the participants who work in private sector think that requiring a contractor to review the scope of projects and verifying that they are correct improves project performance as seen in Figure 4. Alofi (2015) found that around ninety-five percent (95%) of the participants who work in public sectors think that the projects performance will improve by requiring a contractor to review the scope of projects and verify they are correct as seen in Figure 4.

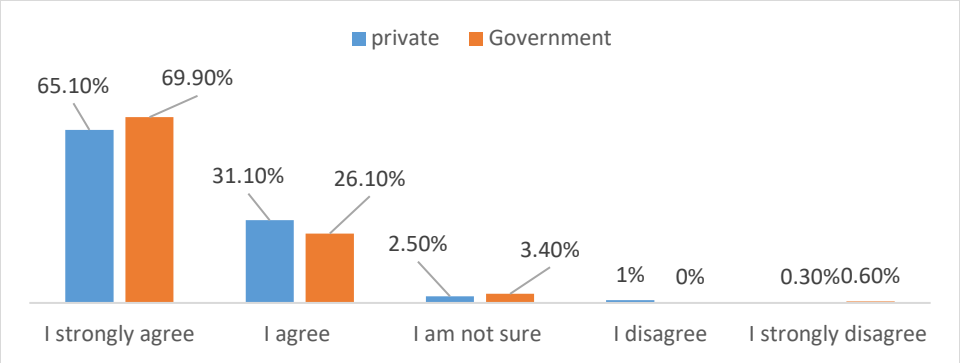


Figure 4: When contractors have a plan before a contract is signed, the performance of the project improves, thus minimizing losses in time and money.

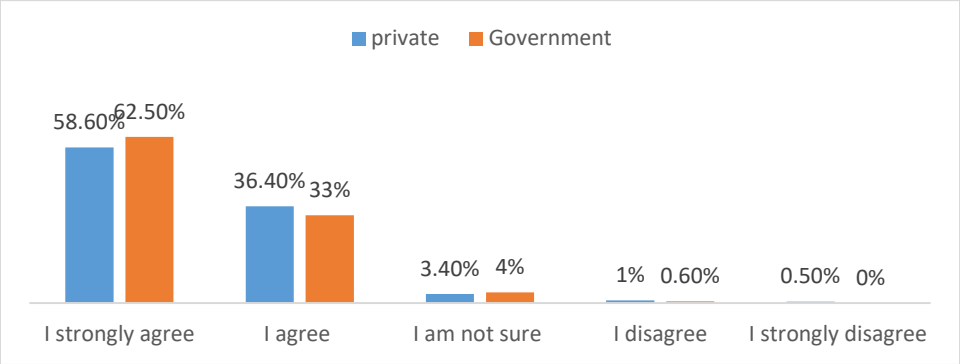


Figure 5: Requiring contractors to review the scope of projects improves projects' performance.

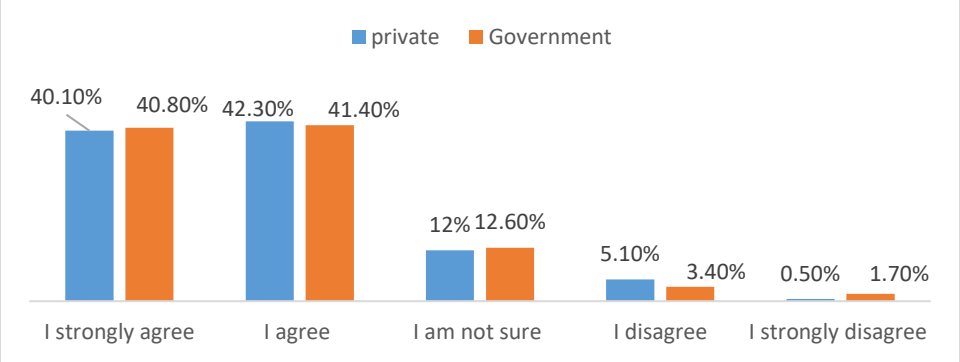


Figure 6: Requiring contractors to resolve all owner concerns before a contract is signed improves projects' performance.

As seen in Figure 5, regarding the owners' concerns, approximately eighty-two percent (82%) of the participants who work in private sectors think that requiring contractors to resolve all owners' concerns before a contract is signed improves project performance. Alofi (2015) found that about eighty-two percent (82%) from the participants who work in public sectors think that the projects performance will improve by requiring contractors to resolve all owners' concerns before a contract is signed as seen in Figure 5. Regarding the weekly risks reports, around ninety percent (89.7%) of the participants who work in the private sectors and approximately ninety-two

percent (92.1%) from the participants who work in the public sectors support using the risks weekly reports to measure and improve projects as seen in the Figure 6.

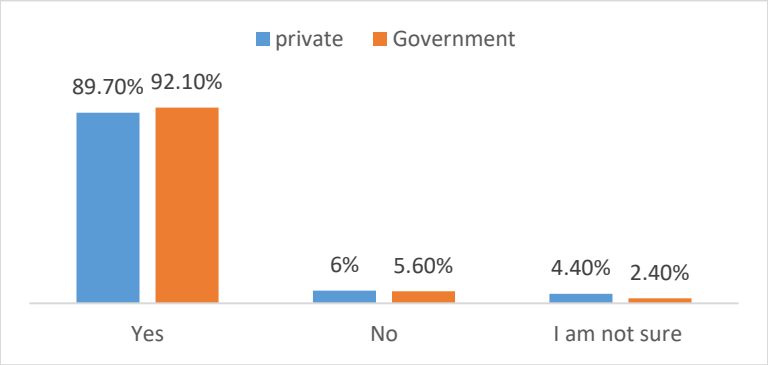


Figure 7: The weekly reports of the risks and tasks at projects would be measured and improve all project tasks.

Survey Analysis

The survey was accurately designed, and the data has been collected through a large number of professionals in SA who are interested in the SA procurement and contractors' system. The results reflect the great interest of the participants, who work in both private and public sectors, in the development of the current procurement system. The results were closely matched between private and public sectors in all statements. The participants who work in the government sectors are more willing to develop the procurement system compared with the participants who work in the private sectors through two statements: contractors' evaluation and weekly risks reports. The difference between the two sectors is about 2.4% in the both statements in favor of the public sector. This reflects many losses to existing projects caused by the current procurement system in terms of contractors' selection and currently existing standards. Also, the participants who work in the public sector believe that the weekly risk reports (WRR) impact the projects positively.

The result was very similar between the participants who work in the both public and private sectors in three statements: contractors' plans, scope of projects and owners' concerns. However, in one statement, the participants from the private sector are more willing than the public sector in terms of requiring the contractor to identify risks before a contract is signed. About ninety percent (90.1%) from the participants who work in the private sectors and around eighty-nine percent (88.7%) from public sector, which means around 2.5% present more another sector.

A New Composite Model to Increase Performance

The new model is called SVIE Procurement system model. The SVIE is based on results from the survey and PIPS, which has been taken by professional engineers in SA and who have a long experience with the Saudi procurement and contracts system. This model is easy to use by owners or general contractors and does not require special skills or a background to implement it. The model consists of four different phases: Pre-Qualification, Selection, Clarification and

Execution. The model allows any contractor or vendor to enter the competition without preconditions as seen in Figure 8.

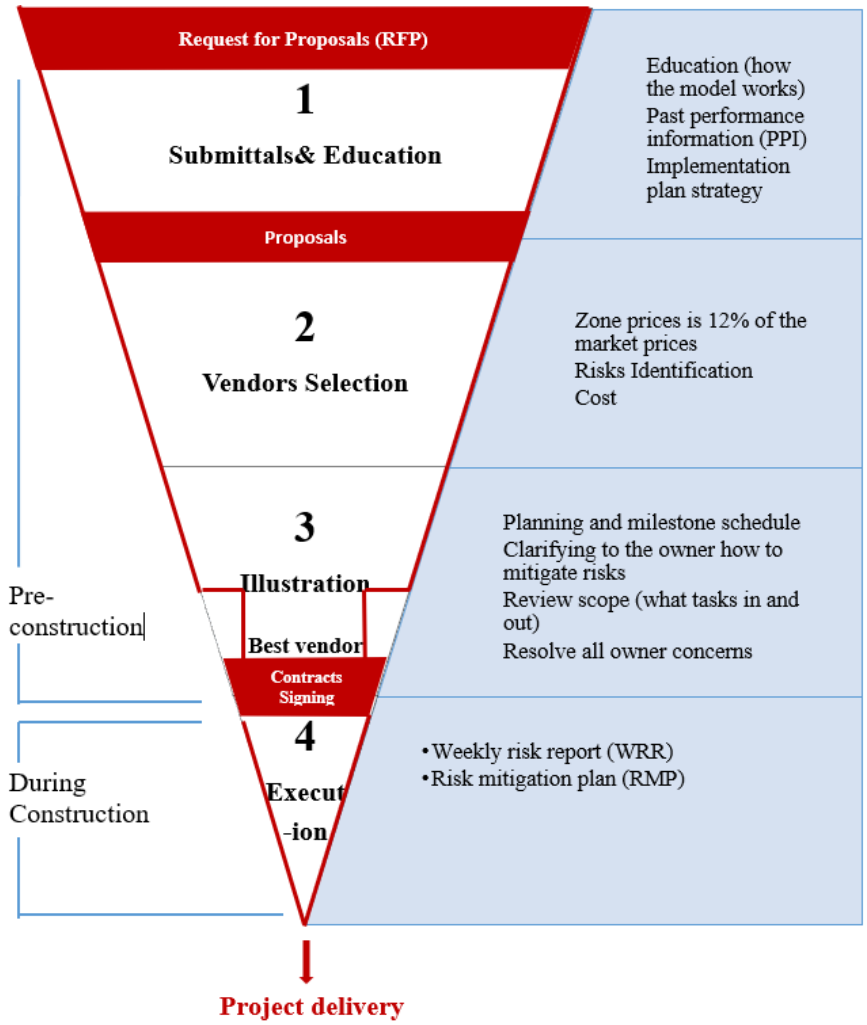


Figure 8: The SVIE Procurement system model is to increase the performance of the Saudi procurement system.

Pre-Qualification

In this phase, contractors or vendors will be trained to know more about how they will be chosen and receive more information about the document submittal process necessary at each phase. This phase is important to overcome many of the questions and observations about the projects. Also, during this phase, the contractors must submit an overall plan strategy, which will be taken in the project and their past performance information (PPI) with references to evaluate them.

Selection

The selection phase focuses on the selection of the contractors or vendors within criteria such as identifying the potential risks of the project, cost and their prices in comparison to the zone prices which is 12% of the market prices. Also, at this phase, contractors will be chosen based on their expertise not only based on cost. The expert contractor or vendor who has been chosen will move to the next phase, the clarification phase.

Illustration
After having been chosen, the contractor or vendor at the selection phase, the winner, moves to the clarification phase, which the is the most important phase of the proposed model. In this phase, the contractor or vendor must submit the overall plan for the project and milestone schedules for each phase of the project. Also, the contractor or vendor should have an explanation on how to reduce the potential risks in the project and develop a plan to deal with those risks alongside a scope review with the owner. In the scope discussion, the contractor or vendor should identify all tasks that occur in or out of the framework of the project. In addition, the contractor or seller should, at this phase, find solutions to all the owner's concerns by using the principle of transparency.

Execution
After signing the contract between all parties, the contractor or vendor begins to execute the project and construction work. During this phase, the weekly risk reports (WRR) should be submitted weekly by contractor or vendor to the owner. The WRR shows the risks that happened or will happen to develop plans to deal with those risks when discovered in the project by using RMP.

Conclusions & Recommendations

The current SA procurement system is causing delays and money losses in previous and existing projects. These issues resulted from the contractors' or vendors' selection process. This leads to selecting unqualified contractors or vendors because the system selects them only based on the lowest price without taking any criteria into account. On another side, the researchers trust one of the best procurement systems in the world, which is called PIPS. The PIPS has been tested during last twenty years more than 1700 times with 98% of users' satisfaction. A questionnaire about SA procurement system improvement has been sent out to 1,396 professionals in the Kingdom of SA. The participants are from both the public and private sectors and have a long experience with the Saudi procurement and contracts system. The questionnaire contains several areas to develop and increase the performance of the Saudi procurement system by adding several new phases into the current procurement system. These new phases ensure the efficiency of contractor or vendor who has been selected. Also, the new phases lead to select the most expert contractor or vendor. The expert always increases the project success and reduces losses in time and money.

The questionnaire results are as follows:

- Around 94% of the participants who work in the private sectors and 96% of them who work in government sectors agreed to evaluate the previous contractors' projects before the contract is signed to ensure their efficiency for the next project.
- Approximately 90% of the participants agreed that identifying risks before a contract is signed would improve project performance.
- 96% of the participants who work in the private sectors agreed that contractors having plans before a contract is signed improves the performance of the project, thus minimizing losses in time and money.

- Around 95% of the participants who work in private sector think that requiring contractors to review the scope of projects and verify that they are correct improves project performance.
- 82% of the participants who work in private sectors think that requiring contractors to resolve all owners' concerns before a contract is signed improves project performance.
- Approximately 90% of the participants who work in the private sectors and approximately 92% of the participants who work in the public sectors support WRR to measure and improve projects.

References

Al Turkey. (2011). The reality of projects in terms of organization and structure, and the reasons for success and failure In Saudi Arabia. Alwatan Newspaper. [online] accessed on 12 March 2015 available from http://www.alwatan.com.sa/Local/News_Detail.aspx?ArticleID=49126&CategoryID=5

Al-Abidien, Z. HM (1983), About the effect of delay penalty on the construction of projects and modification proposal. Albogamy, A., Scott, D., & Dawood, N. (2012). Addressing Construction Delays in the Kingdom of Saudi Arabia. International Proceedings

Al-Barak, A. A. (1993). Causes of contractors' failures in Saudi Arabia. Master of Science thesis, KFUPM, Dhahran, Saudi Arabia.

Albogamy, A., Scott, D., & Dawood, N. (2012). Addressing Construction Delays in the Kingdom of Saudi Arabia. International Proceedings of Economics Development & Research, 45.

Al-Ghafly, M. A. "Delays in Construction of Public Utitlity Projects in Saudi Arabia, KFUPM, Dhahran, Saudi Arabia." (1995).

Alhazmi, T., & McCaffer, R. (2000). Project procurement system selection model. *Journal of Construction Engineerng and management*, *126*(3), 176-184.

Al-Kharashi, A., & Skitmore, M. (2009). Causes of delays in Saudi Arabian public sector construction projects. *Construction Management and Economics*, *27*(1), 3-23.

Alofi, A. (2015). *Upgrade the Saudi Arabian Procurement System Delivery Method* (Doctoral dissertation, ARIZONA STATE UNIVERSITY).

Alofi, A., Alhammadi, Y., Kashiwagi, D., Kashiwagi, J., & Sullivan, K. (2015). Upgrade the Saudi Arabian Procurement System Delivery Method. *Journal for the Advancement of Performance Information & Value*, *7*(1).

Al-Sultan, A. S. (1987). *Determination of construction contract duration for public projects in Saudi Arabia* (Doctoral dissertation, Master thesis, KFUPM, Dhahran, Saudi Arabia).

Altolany, S. (2013, October 27). Contractors are demanding the development of government procurement and contracting systems. Retrieved December 31, 2015, from http://www.alyaum.com/article/3100418

Assaf, S. A., & Al-Hejji, S. (2006). Causes of delay in large construction projects. International journal of project management, 24(4), 349-357.

Kashiwagi, D. (2014). 2014 best value stander Mesa, Arizona: Kashiwagi Solution Model (KSM)

Kashiwagi, D. (2014). 2014 information measurement theory with the "Kashiwagi Story"Mesa, Arizona: Kashiwagi Solution Model (KSM).

King Abdulaziz City for Science and Technology. (n.d.). Retrieved 2011, from http://www.kacstsa.org/2014/ar/building_technologies/reports.aspx

Langdon, D. (2012). World Construction 2012. *An AECOM Company. Najdeno*,*30*.

Performance Based Studies Research Group. (2014). Retrieved June 11, 2015, from http://pbsrg.com/

Performance Based Studies Research Group. ARIZONA STATE UNIVERSITY (2016).

Approach to Improve Edible Bird Nest Quality & Establishing Better Bird Nest Cleaning Process Facility through Best Value Approach

Tan Kok Hong, Chia Fah Choy, and Alan Ong Han Kiat
Universiti Tunku Abdul Rahman
Petaling Jaya, Malaysia

Edible bird nest industries have existed for more than a century; however, it has been going through a few revolution cycles. As harvesting EBN from the natural habitat in the dark and dim limestone caves to the modern purpose-built swiftlet farms, the quality and quantity of the bird nests have risen to a new level. This success of changing the habitat of swiftlet colonies is revolutionary because the ease of rescuing bird nests from life-threatening experiences to a safe environment has improved. Furthermore, with a synthetic environment, the quality of bird nests has improved with decreased levels of pollution and the colony`s population increased due to better growth along with protection from predators. On the downside, edible bird nest cleaning processes experienced very few changes since the discovery of edible bird nests. The method of cleaning remains unchanged. Several machines have been introduced to replace human labor and the results are either ineffective or undesirable. In this study, existing practices were observed and analyzed by identifying the area of opportunity for improvement. A new proposed method has been implemented to enhance the quality and nutrients of the bird nests. The experimental methodology has been employed to analyzes a set of samples obtained from both cleaning methods. The results show a smaller expansion rate under the current method in processing edible bird nest; hence, the possibility of nutrients preserved has increased by 30% under the new method. The percentage of crude protein concentration in the newly improved method was 50.25% whereas in the traditional method, it was only 31.16%. This clearly indicates the difference of 19.09% nutrient lost between the new improved method and traditional cleaning method.

Keywords: Bird nest cleaning, bird nest processing, edible bird nest, swiftlet, best value approach.

Introduction

Edible bird's nest (EBN) is a precious functional food and therapeutic herbal medicine that has been used for several hundred years in China. It is known as the "Caviar of the East" (Marcone, 2005) in Chinese communities around the world. EBN mainly comprises a secretion of the salivary gland of several species of *Aerodramus genus* (formally collocallia) (Gray, 1840) in the Apodidae family, such as *Aerodramus fuciphagus* and *Aerodramus maximus*. These birds are found predominantly in Southeast Asia, e.g. Thailand, Vietnam, Indonesia, Malaysia and Phillipines (Marcone, 2005).

The therapeutic effects of EBN, including replenishing lung deficiency and expelling phlegm, were recorded in Chinese literature first published in 1695 (Zhang, 1959). In view of these therapeutic and beauty–rejuvenating applications, EBN is much in demand in the international

market. The estimated market for EBN in 2004 was about HK$3 billions in Hong Kong alone (Leung, 2004).

Generally, the edible-nest swiftlets are cave dwellers; their nesting areas are usually inaccessible for humans and located in dim (or completely dark) sites in limestone caves. They are widespread in the Indian Ocean, South East Asia, North Australia, and the Pacific Islands (Thomassen et al., 2003) and are predominately discovered in Asian countries, such as Malaysia, Indonesia, Thailand, Vietnam, Philippines, and China, etc. (Marcone, 2005) with Indonesia as the biggest and the Malaysia Borneo provinces of Sarawak and Sabah being the second biggest resource (Hobbs, 2004).

Although the high consumption of EBN poses a perennial threat to the survival of swiftlet and proposals for limitations on EBN trade are constantly being raised, the free EBN trade remains unchanged because swiftlets are currently not listed on the endangered species lists of the Convention on International Trade on Endangered Species of Flora and Fauna (CITES) due to their large population (10 millions). Nevertheless, the countries supplying EBN have promised to protect swiftlets while harvesting the EBN to maintain supplies to an ever-growing market around the world (Animals Committee of CITES, 2000).

Edible bird nest industries have existed for more than a century, from the natural habitat in the dark and dim limestone caves to the modern purpose-built swiftlet farms, the quality and quantity of the bird nests have risen into a brand-new level. This success of changing the habitat of swiftlet colonies is one of revolutionary because it has improved the ease of rescuing bird nests from life threatening experiences to safe environment. In the natural cave environments, swiftlet nests can only be harvested twice a year. This affects the quantity of bird nests as the same bird nests may be reused by the same swiftlet or other. The quality of bird nests may also drop substantially when the environment of nature cave is not clean and other insects or animals such as bats and lizards may further pollute the nests.

With a man-made environment, all the guanos can be cleaned weekly and the nests harvested fortnightly to maintain the quality and quantities of bird nests. At the same time, swiftlet colonies can achieve better growth and longer lifespan with better protection from their predators. Swiftlet farming in Malaysia started late last century and it mushroomed during the last few years with estimate 60,000 to 80,000 farms in Malaysia. It has been identified as one of 16 entry point projects that ‘catalyzes the establishment of market driven, industrial scale and integrated agriculture-related businesses’ under the National Key Economic Areas (NKEA). However, edible bird nest cleaning process has not changed much and sufficient improvement since the discovery of EBN.

In August 2011, China had ban all bird nest from Malaysia due to an alarming scandal which blew up in Zhejiang when its industry and commerce bureau discovered that the average level of nitrate in 537 “blood nest” samples was 4,400mg/kg, far exceeding the national cap of 70mg/kg. Most of the bird’s nests were claimed to be originated from Malaysia (Tho, 2014). The news was a serious blow to the swiftlet industry in Malaysia, which suffered sharp dip of unprocessed bird nest price by 60% when local prices for grade “A” unprocessed bird’s nests plunged from

RM4,000 per kg in year 2010 to between RM1,200 and RM1,500 per kg in the local market that year (Lee, 2013).

In September 2012, Malaysia and China signed a protocol on bird's nests entry into China, which touched on the aspects of examination, quarantine, and hygiene. Fifteen Malaysian companies submitted their applications to export their bird's nests to China in March last year. They were subjected to evaluation by Chinese authorities. Nine gained the conditional pass in June but only eight of them were given the final approval (Tho, 2014). The lift of the ban came as new hope to this long-suffering industry. However, obtaining the final approval from China authorities seems to be a stiff challenge for most of the downstream producers.

During the literature review of bird nest cleaning process, only two papers stated the process of EBN cleaning (Vimala et al, 2012 and Jong et al, 2013). However, both processes involve repetitive spray of water to soften the bird nest for cleaning of feathers as well as molding of bird nest back to its original shape. The detailed process involves five basic steps, which are washing with brushes, softening with water, cleaning with pincer, molding or binding with thread and drying with fan and heating with an incandescent light bulb (Jong et al, 2013).

In the past five years, the retails prices of EBN reduced by 50% from RM 8,000 per kilo to merely RM 4,000 per kilo. This is due to non-standardization of cleaning processes and the lack of proper cleaning guideline. A research on the nutritional value of EBN showed a substantial reduction on fat (0.01% to 0.03%) and ash (3.5% to 6%) contents between the unclean and clean nests. Moreover, cleaned bird nest's moisture contents increase from 31% to 92% was due to the cleaning process (Hamzah et al, 2013).

It remains a challenge for the actual nutrients contents in bird nests to be preserved during the cleaning process and most of the processing plants in Malaysia fail to meet the standard requirement of HACCP and CNCA of China. As the main concern from the stakeholders of industries was obtaining the permit from CNCA China to export their clean bird nests to China, the non-standardization of their cleaning process jeopardizes their market share and value of their products.

Objectives

The objective of this research is to analyze current cleaning methods, by identifying the areas of opportunity for improvement. By adopting best value approach as comparison with traditional approach, the new proposed cleaning method focuses to minimizing its exposure to possible contamination, and to preserve its original nutrients.

Research Methodology

In search of an improved cleaning method, the best value approach by Kashiwagi is deployed. In the paper, Kashiwagi reiterates that by engaging the expert to plan and manage the entire project from beginning to the end, the risk can be shifted to the vendor, thus providing the best value for the lowest price (Kashiwagi, 2011). By implementing best value approach, the existing processing method is investigated to identify the area of opportunities for further improvements.

With data collection, issues that are not conforming to requirements would be resolved through the newly proposed cleaning process.

In the second step, it is to study both processing methods and comparing through SWOT analysis. A set of clean bird nest sample was obtained and tested to ensure the effectiveness of the new proposed process.

Data Collection

All the information in this research is collected through interview and observation. Data is compared and analyzed from the perspective of economic, functionality, environmental impact and sustainability.

Current Approach in Establishing the Cleaning Process Facility

Bird nest processing has been established since last century. However, the approach in establishing the processing facilities remains the same till present. In this paper, the author tends to analyze the current issues and problems encountered to establish a better approach to mitigate the risk and increase the quality output.

In the last decade, the traditional cleaning process was regarded as a trade secret in which the owner of the business will not reveal to any outsider other than their immediate family members. However, the awareness of the consumers toward quality control and demand for better quality has forced the traditional businesses to abandon their well-kept secret, in search of a better approach. Through observation of cleaning processes in the past 10 years, most business owners have been going through the process of piecemeal approaches in establishing the cleaning facilities.

In Malaysia, the history of bird nest cleaning only dates to around 15 years. During infancy period, there were few established experts or trainers. Therefore, any business owners or investors will search for a trustworthy expert by attending the seminar or training. Most business owners will start with the basic skill they acquired through training in a few days. They may have gone through a few rounds of seminar to sharpen their skills until they are ready to train their respective workers.

Through observation, the process can generally be summed up in a few steps (Figure 1). The initial step of searching the right cleaning method may be time consuming and with an uncertain outcome. Owners may also face new problems that may need to modify the cleaning procedure. This will cause the issues of unstable quality control and lacking proper procedure.

With constant change in the cleaning procedure, the planning of facilities becomes ineffective. Overlapping in handling process occurred and these complications may lead to higher risk of contamination and resulting in a compromised quality of the final product. This is the constant pattern of traditional process owners as they modify, or upgrade facility based on customer demands for better quality.

Figure 1: Phases of setting traditional cleaning process.

Traditional Cleaning Process

The traditional cleaning process has been implemented for more than half a century. It has been passed on from generation to generation without much improvement. This process is time consuming and without scientific proof or analysis. As shown in figure 2, the raw bird nests harvested from the swiftlet farms or limestone caves go through the process of sorting according to its grade. This is to facilitate the value-added diversity of EBN products. The less feathers or impurities will be preserved for the premium grade bird nests followed by normal grade. Bird nests, which are hard to clean will be categorized as low-grade products such as biscuits or bird nest strips.

After the sorting process, raw bird nests will be soaked in clean water for further cleaning. During the process, most of the dusts or surface impurities will float up; the bird nest starts to absorb the water and expands in size by 20% to 30%, with an increase of five times its original weight. The condition of the nest appears to be soft and sticky. Therefore, it is easier for the workers to pick out the feathers with forceps or tweezers. This process may take 20 to 30 minutes for a skilled worker to do and it depends on the cleanliness of the raw bird nest.

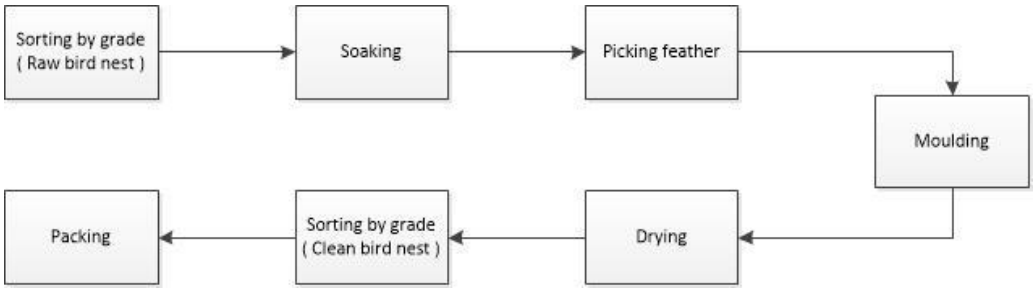


Figure 2: Traditional cleaning process flow chart.

The process of molding requires a set of plaster mold or stainless-steel netting, like the half cups (Figure 3). By placing moist bird nest into the plastic mold, the cleaned bird nest is mold pruned into its original shape upon drying up. The plastic mold also requires some clips or tools to hold the bird nest in place during drying. Most of the bird nests will be dried under low heat cabinet with assistance of a direct fan blowing.

Figure 3: Plastic Mold.

One of the weaknesses of this process is that the molding and drying processes are time consuming. As the bird nests expend during the soaking process, it is hard to reshape back to its original size. The quality will be downgraded, and the nutrients content will be reduced quite substantially.

Best Value Approach to Establish Cleaning Process Facility

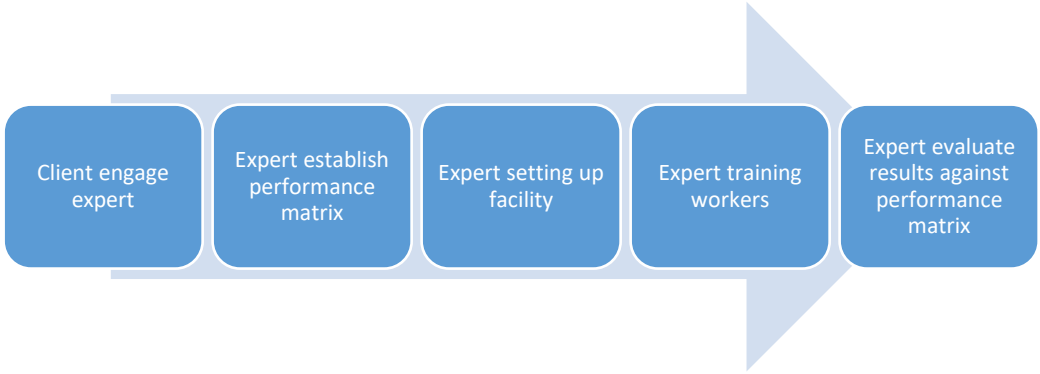


Figure 4: Phases of setting cleaning facility through best value approach.

The new effective approach we propose is to set up a cleaning process with the best value approach (Kashiwagi, 2017). The theory of this method does not depend on the knowledge or expertise of the client but rather the expertise of vendors.

Upon engaging the expert, it is paramount that the expert is fully in charge of the whole project, whereas the client would be out of picture. It is now entrusted to the expert to develop a performance matrix or indicator before setting up the facility. Without the interference from the client, the expert could make immediate decisions to reduce time wastage and increase efficiency.

When the facility is fully functioning, the expert would evaluate the facility with actual operation and engage workers in training at the same time. This would allow the expert to fully analyze the efficiency of the facility with minor adjustments, if required.

New Improved Cleaning Process

The new improved cleaning process (Figure 5) was developed through a scientific analysis of bird nest properties and its characteristics. The bird nest is built completely from salivary gland; it is sticky and contains high percentage of water. According to previous research, the moisture content is frequently used as an index of stability and quality of bird nest. (Kok and Thrisingam, 2011). During the drying process, it is slowly hardening into a stable state to hold up the weight of the eggs and the chick.

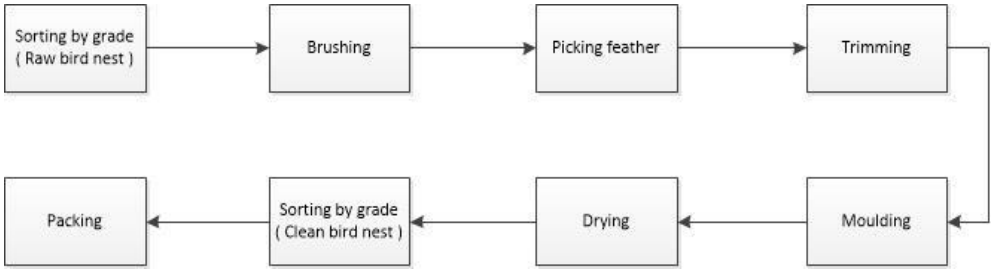


Figure 5: New improved cleaning process flow chart.

Moisture control after the sorting process is taken into consideration in the new approach. The raw bird nest is required to brush off any impurities or dusts covering the surface. The brushing process is introduced base on the expert's input to control the moisture and eliminate contamination through excessive water contact. During this process, the raw bird nest is exposed to small amounts of water and causing the bird nest to turn into a soft and elastic resilient condition. It is placed into the container to allow the bird nest to expand slightly. The process of picking the feathers will be under a stage of semi-dry condition. This is to maintain the nutrients as well as the original shape of the bird nest. Cleaned bird nests will be trimmed away and any excessive edges to be placed into the plastic mold as shown in Figure 3. Due to the controlled expansion and moisture, the drying process does not require any heat. It is placed within a ventilated cabinet until the bird nest dries completely to its original shape. This approach has shortened the time of molding and drying. It also preserves the nutrients and quality of bird nest. The risk of contamination through water or air can be reduced or avoided altogether.

SWOT Analysis

Through SWOT analysis, we identified the parameter of cleaning process and key area of improvement. Both cleaning processes can be summarized as in Table 1.

Table 1: SWOT analysis of both cleaning process.

	Traditional Cleaning Process	**New Improved Cleaning Process**
Strength	Easy to train the workers Easy to set up	Less wastage Better quality Less contamination
Weakness	Higher wastage Low quality Higher chance of contamination	Required more skill More steps or processes Longer training time
Opportunity	More area of improvement More saving on the wastage	More skill improvement Better control on worker mobility
Threat	Workers reluctance to change More investment needed to improve the process	Required strict quality control New workers may find it difficult to master the skill

From the analysis, it is realized the reasons behind most of the traditional cleaning process remain unchanged mainly due to the reluctance of existing workers toward finding new ways to improve the current process and the increased cost incurred by the operators.

Several risk factors faced by the traditional cleaning entities were also observed. The owners reiterated that the excessive rectification cost on their equipment and upgrading was beyond their initial resources and labor planning. Despites of constant changes on the facilities, quality control of the processes become complicated was either difficult to maintain or improve. For those who are incapable of meeting market demand or upholding of their quality, they may end up winding down their business or phase out from the industry.

Matrix Indicator - Expansion Test

On both cleaning processes, a set of samples collected at the end of cleaning process. Both edible bird nests were weighed before the experiment. The dry bird nests were then being placed into a glass bottle with warm water for 20 minutes (Figure 6). Again, the bird nests were drained and placed on a scale to record the weight. The statistical data for the comparison of both cleaning processes in term of weight and expansion rate was tabulated in Table 2.

Figure 6: Expansion Test.

Table 2: Expansion Test.

Edible Bird Nest	Original Weight (Gram)	Weight After Soaking (Gram)	Expansion Rate (Ratio)	Percentage of Expansion
Raw Bird Nest (Unclean)	5.52	45.02	8.2	100%
Clean bird nest using Traditional Method	4.73	25.11	5.3	64%
Clean bird nest using New Improved Method	4.89	37.73	7.7	94%

Matrix Indicator – Crude Protein Test

According to the paper by Marcone, (2005) it was reported that the composition of EBN from both Malaysia and Indonesia was of 62.0% crude protein, 27.3% carbohydrate, 7.5% moisture, 2.1% inorganic ash and 0.14% lipid. The major portion of the detected nutrient was crude protein and it is also comprising of all the major sialic acid components.

To determine the nutrient content of bird nest to substantiate the argument of nutrients lost through the process of cleaning, crude protein test was conducted to address the effectiveness of the new cleaning method.

1. Biuret Method

Biuret Method was chosen in this study. The sample of clean bird nest was prepared as sample A and B. Biuret Method involved the preparation of solution of bovine serum albumin as standard and Biuret reagent which consisted of copper sulfate pentahydrate CuSO4·5 H2O c = 13.0 mmol·l-1, potassium sodium tartrate KNaC4H4O6·4 H2O c = 32·0 mmol·l-1 and NaOH c = 0.6 mol·l-1. The process of the test involved dilution of 0.5 ml of sample with 3 ml of Biuret reagent. The tubes can set for 30 minutes at room temperature and the absorbance was measured at 540 nm. (Copeland, 1994).

2. Preparation of the standard and sample

Approximately 0.4 gram of protein was measured on the scale with the tube in standing position and was then diluted with 400 ml of distilled water. Protein standard was prepared according to Table 3 below:

Table 3: Preparation of protein standards.

Mg/ml	Protein Standard	Distilled water
2	2 ml	8 ml
4	4 ml	6 ml
6	6 ml	4 ml
8	8 ml	2 ml
10	10 ml	-

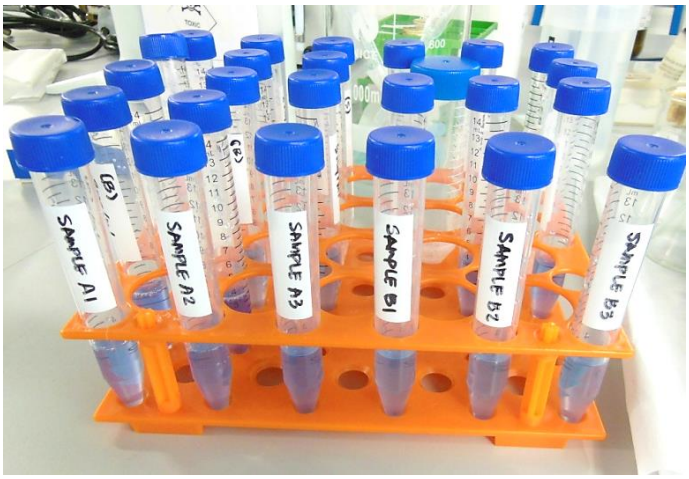


Figure 7: Triplicate sample with biuret reagent.

Two sets of samples (Sample A and B) of cleaned bird nest were obtained and prepared with double boil for 45 minutes at 100 °C boiled water. Samples were filtered with filter paper to separate the solid objects. A total of three sets for each sample with 0.2 ml of bird nest and 0.3 ml of distilled water were prepared (Figure 7). Approximately 3 ml of biuret reagent was added into each standard and sample with an interval of 1 minute after which the standard and sample could set for 30 minutes.

3. Preparation of spectrophotometer

Spectrophotometer was prepared with blank distilled water at 540 nm. A cleaned container was used for each protein standard and absorption reading was recorded in Table 4.

4. Result

Table 4: Result of Absorbance.

Tube	Concentration	Absorbance
1	2	0.08
2	4	0.122
3	6	0.152
4	8	0.185
5	10	0.231
Sample A1	5.89	0.152
Sample A2	5.89	0.152
Sample A3	6.33	0.160
Sample B1	3.87	0.115
Sample B2	3.55	0.109
Sample B3	3.82	0.114

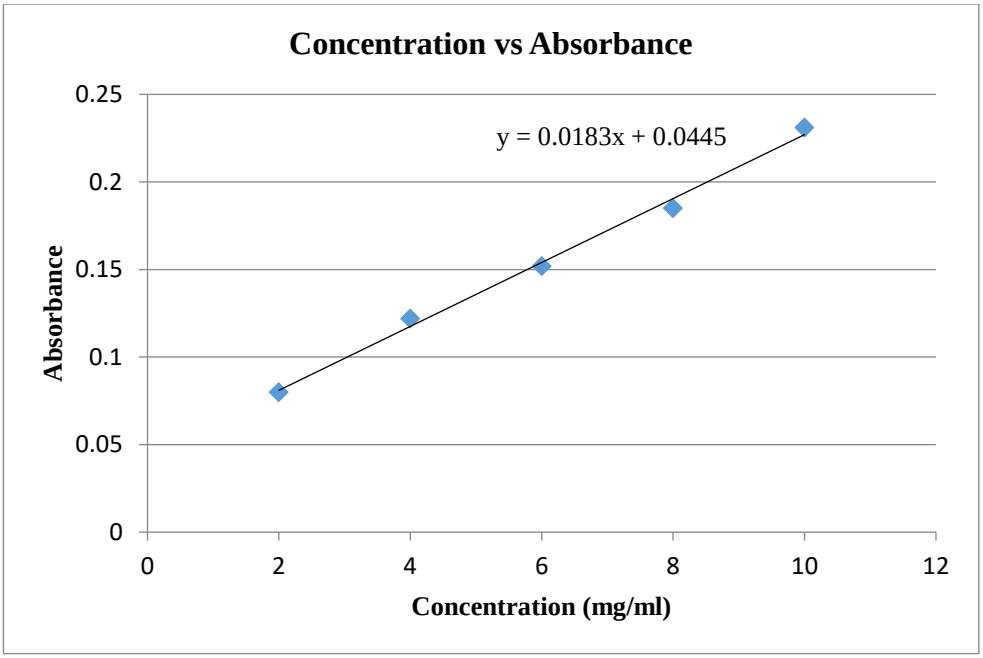


Figure 8: Crude protein concentration.

Table 5: Percentage of Protein Contain in 12mg/ml of processed bird nest.

Sample	Protein (mg/ml)	Percentage
Sample A New Improved Method	6.03± 1	50.25%
Sample B Traditional Method	3.74±1	31.16%

Conclusion

The analysis and expansion experiment showed that the new proposed cleaning method was able to preserve the EBN nutrients, shape, and its original properties. A set of raw bird nests (unclean) had been used as a standard measurement for the test. The results showed that full expansion of raw bird nest was 8.2, clean bird nest (Traditional) was 5.3 and clean bird nest (Improved) was 7.7 times of its initial weight. Therefore, the current or traditional processing method may cause possible contamination through water and loss of nutrients by 36%, and the newly improved method could preserve the nutrients of up to 94%.

The result from the Table 5 showed the percentage of protein concentration in new improved method was 50.25% and traditional method was at 31.16%. It clearly indicates the difference of 19.09% nutrient loss from the traditional cleaning method (Table 6).

Table 6: Comparison result of Expansion test and crude protein test.

Sample	Expansion Rate	Percentage of losses	Percentage of Crude protein contain	Percentage of losses
Raw bird nest	100%	Nil	62% * (a)	Nil
Traditional method	64%	36%	31.16% (b)	30.84% (a- b)
New improved method	94%	6%	50.25% (c)	11.75% (a – c)
*Note. The values of raw bird nest crude protein referring to (Marcone,2005)				

The best value approach of analyzing current cleaning process and re-engineering the process by engaging an expert from beginning have produced much desirable result. The end results could easily be justified through the fundamental matrix set from the beginning. This study concludes that the best value approach indeed has been adopted for a good performance of the process, and a process recommended for adopting the best value expressively.

Recommendation

It is recommended the best value approach for any new investors or business owner. The system can reduce owner's risk by engaging an expert to plan and execute the entire facility from beginning to the end. Figure 8 (Horstman, 2013) shows the best value approach process, where flowing through three stages could eliminate repetitive process from traditional piecemeal process. The new improved cleaning process could also mitigate the risk from the beginning and the quality of edible bird nest could be improved through well executed design and planning.

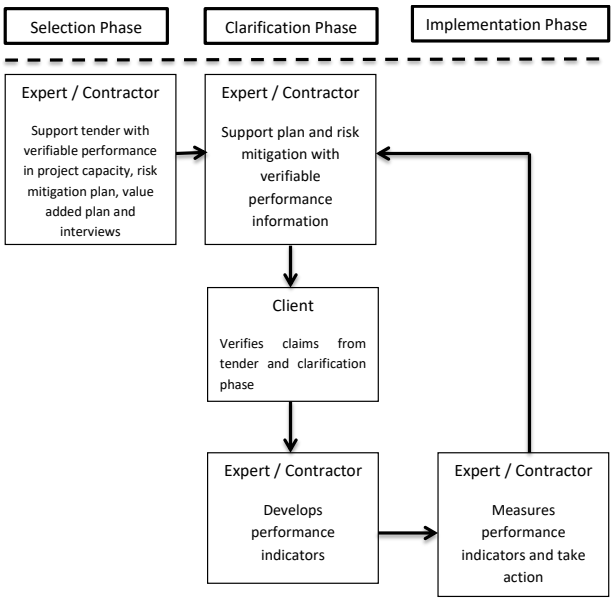


Figure 8: Best value approach (Horstman, 2013)

References

Animals Committee of CITES (2000). Convention on International Trade in Endangered Species of Wild Faun aand Flora. [WWW document]. URL http://www.cites.org/eng/cop/11/doc/11_01.pdf

Copeland, R. A. (1994). Methods for protein quantitation. *In Methods for protein analysis* (pp. 39-58). Springer, Boston, MA.

Hamzah, Z., Ibrahim, N. H., Sarojini, J., Hussin, K., Hashim, O., & Lee, B. B. (2013). Nutritional properties of edible bird nest. *Journal of Asian Scientific Research*, 3(6), 600.

Horstman, A. (2013). *Performance Indicators in the Best Value Approach*. Master Thesis, University of Twente.

Jong, C. H., Tay, K. M., & Lim, C. P. (2013). Application of the fuzzy failure mode and effect analysis methodology to edible bird nest processing. *Computers and electronics in agriculture*, 96, 90-108.

Kashiwagi, D. (2017). How to Know Everything Without Knowing Anything. *Kashiwagi Solution Model Inc. Mesa, Az. Publisher: KSM Inc. Chapter 12, 66.*

Kok, S. C., & Thurisingam, C. (2011). *Raw edible bird nest (EBN) and authenticity requirement by laboratory analysis.*

Lee.J. A. growing nest egg, *The Star*,(2013) [WWW document]. URL http://www.thestar.com.my/Business/SME/2013/08/01/A-growing-nest-egg-For-one-company-the-growing-popularity-of-birds-nest-products-is-providing-lucrat.aspx/

Leung, C. Y. (2004). Three billions market competition for edible birds nest shops.*Economic Digest*, 1197, 68-69.

Marcone, M. F. (2005). Characterization of the edible bird's nest the “Caviar of the East”.*Food research international*, 38, 1125−1134.

Tho,X.Y. A step up for bird’s nest trade, *The Star*,(2014) [WWW document]. URL http://www.thestar.com.my/Opinion/Columnists/Check-In China/Profile/Articles/2014/01/17/A-step-up-for-birds-nest-trade/

Vimala, B., Hussain, H., & Nazaimoon, W. W. (2012). Effects of edible bird's nest on tumour necrosis factor-alpha secretion, nitric oxide production and cell viability of lipopolysaccharide-stimulated RAW 264.7 macrophages. *Food and agricultural immunology*, 23(4), 303-314.

Zhang, L. (1959). Ben Jing Feng Yuan. Shanghai: *Shanghai Science Technology Press.*

Application of the Best Value Approach in Procuring ERP Services in a Traditional ICT Environment

Isaac Kashiwagi (Msc)
Delft University of Technology
Delft, Netherlands

Dean Kashiwagi (PhD, Fulbright Scholar, PE)
Kashiwagi Solution Model, Inc.
Mesa, Arizona, United States

Len Gambla
Independent Author

The ICT industry has struggled with performance for years. Tools, processes, and techniques have been developed in attempts to improve performance, however, the level of performance has not significantly improved. The Best Value Approach has been proposed to increase both the procurement and execution of ICT projects. This researches focus is to further test, explore and confirm the claims associated with the Best Value Approach and its applicability in the ICT industry. Using case study research, the Best Value Approach was used in the selection of an ERP vendor for a client organization. The research findings confirm the claims of the Best Value Approach to be accurate in terms of being simpler, quicker, lower costing, requiring little expertise from the client and delivering an understandable, non-technical plan including detailed schedule, milestone schedule, and schedule that identifies all stakeholder activity.

Keywords: ICT Industry, performance, Best Value Approach.

Introduction

The Best Value Approach Technology is a revolutionary approach to improving the delivery of services, it is most commonly implemented through the Performance Information Procurement System (PIPS) as both a procurement and project/risk management methodology. The approach was first conceived in 1991 as part of Dean Kashiwagi's dissertation, where he used the Information Measurement Theory (IMT) as the theoretical foundation to identify the construction industry structure and the cause of poor performance (1991). The Industry Structure (IS) model proposes that the buyer or end user (people factor) may be the major source of project cost and time deviation. Initially the BVA was used strictly as a procurement model to select roofing systems and contractors for private organizations including Intel, IBM, and McDonald Douglas. The BVA has since been heavily documented and has spread to be tested in the entire supply chain (construction and non-construction services). Its methodology has been researched and developed in support of professional groups like the International Council for Research and Innovations in Building and Construction CIB and the International Facility Management Association for the last 23 years and has been identified as a more efficient approach to the delivery of professional services. Some of the impacts of the BV PIPS are as follows (Rivera, et al. 2016, Kashiwagi, 2017):

1. Most licensed university technology developed at Arizona State University with 52 licenses issued by the innovation group, AZTech, at Arizona State University. BVA PIPS tests have

been conducted in 32 states in the U.S. and five different countries besides the U.S. (Finland, Botswana, Netherlands, Canada, and Malaysia).
2. Documented performance of over 1,900 projects or $6 billion (1,635 projects, $4B construction and 315 projects, $2B non-construction), customer satisfaction of 9.8 (out of 10), 94% of projects on time and 97% on budget.
3. Research tests show that in procuring of services outside of construction, the observed value is 33% or an increase of revenue or decrease in cost of 33% (Kashiwagi, 2013).
4. The results of PIPS testing have won numerous awards: 2012 Dutch Sourcing Award, the Construction Owners of America Association (COAA) Gold Award, the 2005 CoreNet H. Bruce Russell Global Innovators of the Year Award, the 2001 Tech Pono Award for Innovation in the State of Hawaii, along with numerous other awards.

Outside groups have analyzed the BVA PIPS system multiple times in the last 17 years. However, two investigations, the State of Hawaii audit (State of Hawaii PIPS Advisory Committee, 2002) and two Dutch studies (Duren JV & Doree A, 2008), performed a thorough study on the impact and effectiveness that the BVA PIPS system has had on 100+ unique clients with results that confirmed the high-performance claims.

The Best Value Approach Change in Paradigm

The Best Value Approach's success is primarily due to the change in paradigm required by both the client and vendor. The approach has identified that the problem is humanistic, not technological based. In applying BVA, the client releases control and allows the vendor to take on the expert role, with the client now acting as the utilizer of expertise. The differences in this approach include (Kashiwagi, 2011, Kashiwagi, 2013):

Vendor as the Expert
1. Requires the vendors to assume the client is not an expert in the vendor's field and all information communicated to the client must be simple and nontechnical.
2. Requires the vendors to differentiate themselves in the procurement process by using performance measurements of their key personnel and processes.
3. Requires the Best Value vendor to write the final contract and define the delivered product. Does not use negotiation of price.
4. Requires the Best Value vendor to deliver a complete project plan including milestone schedule, detailed schedule, actions of all stakeholders, risk management plan, performance metrics, and cost breakout before the project is awarded.
5. Requires the Best Value vendor to administer their own contract by tracking their own performance, schedule and deviation of project cost and time deviations.
6. Requires the Best Value vendor to understand that they have full control of the project, and by so doing will manage and minimize the risk and project deviation that is outside of their control, even if caused by the client, or un-foreseen events in the environment.

Client Role as the Utilizer of Expertise
1. Client does not use the contract to manage, direct, and control the vendor but utilizes the vendor's expertise.

2. Client minimizes the need for technical decision making and expertise of the client's technical representatives.
3. Does not require the client to have technical expertise in the service or product they are purchasing.
4. Does not require the buyer to identify a complete requirement of what is being procured at the beginning of the procurement.
5. Does not require the selection committee to have technical expertise to rate or select a vendor. All submittals are non-technical in nature, and technical questions are not asked or discussed until the Best Value clarification phase.
6. Forces the client's project manager (PM) to be a quality assurance-based PM, with nontechnical duties. Defines quality assurance as ensuring that the contractor/vendor is running their quality control/risk management system.

ICT Industry Performance Failure

ICT Project Performance

The information communications technology (ICT) industry has had problems with the delivery of projects that are on time, on budget and that meet client expectations as early as 1968 (NATO Science Committee, 1969). More recently the Standish Group has reported the ICT project failure as high as 83.8% in 1994 and 71% in 2016. Multiple sources have confirmed these claims, in a worldwide literature study investigating ICT project performance, over 25 ICT project performance studies were found, and all unanimously identified similar poor performance (Kashiwagi, 2017). The problem has been identified as global issue with multiple countries such as the United States (US Department of Commerce, 2011), United Kingdom (Public Administration Committee, 2011), Australia (Legislative Assembly of the Northern Territory, 2014), and The Netherlands (The House of Representatives of the Netherlands, 2014) holding nationwide government inquiries to investigate the millions being lost each year because of poor project performance.

Source of Poor Performance

The previous literature identifies that there is no consensus in the industry as the exact cause of the poor performance. A recent literature study compiled 19 previous studies that all formulated unique lists of factors. Among the factors cited include (Kashiwagi, 2018):

1. Poor project planning.
2. Insufficient vendor expertise.
3. Unclear project scope (requirements, objectives, and purpose)
4. Changing project scope (requirements, objectives, and purpose)
5. Committed support of top management and leadership
6. Lack of client involvement
7. Project alignment with business needs.
8. Lack of a project management methodology
9. Poor communication between stakeholders
10. Inability to manage project scope changes
11. Buyer creation of an unrealistic requirement
12. New technology, tools, and/or methods

13. Support and approval of user / client
14. Undefined project success criteria
15. Multiple interacting parts (vendors, systems, organizations, departments, community, etc.)
16. Conflict between client stakeholders (Departments, organizations, etc.)
17. Lack of user education and training
18. Vendor not given enough control over the project
19. Risk management
20. Large project size (duration and cost)

The study further identified that the factors of poor performance can be grouped into six categories (see Table 1):

1. Expertise: The lack of expertise and experience required either on client or vendor side.
2. Scoping: Unclear, unrealistic, unaligned, unmeasured, or changing requirements.
3. Planning: Insufficient methodology, coordination of resources, and project tracking.
4. Relationship: Support from client and correct project roles between buyer and client.
5. Technology: The high difficulty and innovation/newness.
6. Size: The amount of work or resources required in terms of man hours, deliverables, duration, and/or budget.

Of the factor categories, expertise was the most cited by the publications. Scoping, planning and the buyer – supplier relationship ranked relatively similar in importance. However, although the ICT industry is known to be an industry of changing technology and "mega" projects, technology and size were the least mentioned for publication frequency.

Table 1: Factors of Project Failure.

#	Factor Type	% Frequency (19 publications)
1	Expertise	51%
2	Scoping	45%
3	Planning	43%
4	Relationship	42%
5	Technology	24%
6	Size	18%

New solutions have been attempting to address these factors of project failure by minimizing the complexity of the project by focusing on the expertise of the supplier. Three prominent solutions in discussion that have shown documented proof to increase performance include:

1. Minimizing the size of projects (Netherlands house of representatives, 2014; Standish Group, 2013).
2. Use of agile project management to break project up into smaller milestones/projects to get to the final project deliverable (Cutter Consortium, 2008; PMI, 2014; QSM Associates, 2013; Scrum Alliance).

3. Use the best value approach to deliver the project (Duren & Doree, 2008; Kashiwagi, 2013; Rijt & Santema, 2012).

Application of the Best Value Approach in the ICT Industry

There have been multiple studies which have shown the applicability of Best Value within the ICT industry. Six of these studies include:

1. Case Study with the State of Oklahoma COTS-IT Tax software (Kashiwagi, 2014). The project tasked the vendor with implementing a developed and commercially offered Commercial off the Shelf Integrated Tax Software (COTS-ITS) as the primary technology tool to manage all taxpayer data and account information. Utilizing the BVA the state was not expected to deliver a detailed scope requirement but a high-level expectation of the product. This new approach minimized their RFP from over 15 pages down to 1 page. The results included a selected Best Value vendor that was able to successfully develop a full detailed plan in less than 2 months. The project finished on time and on budget with no change orders. The expert vendor cut the government's cost by 40%.
2. Case Study with a traditional Large ICT vendor and client (Kashiwagi, 2014, Rivera, 2014). Arizona State University, the largest university in the United States, applied the Best Value Approach to their IT networking services. The results included: the ability to procure ICT services without a complete scope requirement, identification of a high performing vendor, a complete and executed proposal which offered increased capability to the university at a lower cost.
3. Case Study with Schuberg Philis (SBP) (D. Kashiwagi & I. Kashiwagi, 2014). SBP is one of the ICT companies in the Netherlands that is known for their high performance and unique company structure. The SBP company structure and practices follow the Best Value Approach principles and methodology. The company has shown to deliver over 991 projects, with their large projects reporting an average of 89% on time, 95% on budget and 93% with satisfied clients. The study results conclude that there are high performing experts within the industry and when the BVA practices are applied correctly, they will deliver high performance.
4. Case Study with a traditional Large ICT vendor and client (Kashiwagi et al. 2015). The Port of Rotterdam in the Netherlands procured an ICT project using the Best Value Approach in a traditional ICT environment. The study findings identified the implementation and project as a success. The findings also identified the challenge in the change in paradigm the BVA requires on both the client and vendor side.
5. Case Study with traditional Large ICT vendors sales and marketing group (Kashiwagi et al. 2015). The ICT vendor's sales and marketing core team have become experienced with the Best Value Approach and have applied it to the selection and planning (clarification) process of their projects. The vendor was able to consistently win bids by demonstrating their expertise to the client and providing an acceptable project plan. The findings show the potential impact when a vendor applies the BVA correctly.
6. Case Study with Telephone Facilities (Logemann & Kashiwagi, 2017). The municipality of Eesmond in the Netherlands ran a pilot Best Value Project with the Telephone Facilities which 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 Best Value Approach was implemented from selection to execution of the project. The results showed the highest quality vendor identified for the lowest cost, below budget and completion of the project on time, on budget, with high client satisfaction.

The case studies identified that:

1. The BVA can procure projects without a complete requirement including detailed specifications of how and what will be delivered.
2. The BVA can procure projects with little expertise in the service being procured.
3. The BVA can procure projects faster and at a lower cost than traditional methods.
4. The BVA can identify high expertise for the lowest cost.
5. When followed correctly the BVA will deliver high performance.
6. There is sufficient expertise within the industry capable to plan and execute projects successfully.
7. It is a change in thinking for clients and vendors to operate in the Best Value Approach paradigm.

Research Question & Methodology

The Best Value Approach has had multiple individual and longitudinal studies within the construction industry to support and verify the claims of high performance. There are similar cases in the ICT industry however, the documented results have not been as dominant as those in the construction industry. The purpose of this paper is to further test, explore and confirm the claims associated with the Best Value Approach and its applicability in the ICT industry. The research seeks to answer the following main research question:

Can the Best Value Approach be successfully used to identify an ERP services expert?

To answer this research question, a case study research approach has been performed to identify, understand and analyze the results of implementing the Best Value Approach in the procurement of an ERP project. The following methodology was followed:

1. Identify a client within the traditional ICT industry to perform a case study with the BVA.
2. Assist the client in implementing the Best Value Approach in the selection of vendor and planning (clarification phase) of an ERP project.
3. Document the results of the case study test and determine if the project is successful. Success will be determined as being simpler (minimized scope description), quicker, lower costing, and delivering a complete plan including detailed schedule, milestone schedule, and schedule that identifies all stakeholder activity.
4. Identify future actions for the execution of project.

Case Study: Client Organization

Background

The client organization is a Saudi Arabian registered company with more than 40 years of success training the Saudi Arabian National Guard. The client is a recognized world-class leader and provider of technical services, military training, program management, facilities operation and maintenance, educational and vocational training, and logistics support.

The client's leadership's strategic direction is to optimize the organization to be more efficient and effective. The leadership had identified the need for the optimization of many operational functions and roles within the organization. The ERP system was considered a critical piece to this optimization as it would be a catalyst to this change. The ERP system would be used as the change management mechanism to train and transition client employees to the desired optimized organization. For this reason, the ERP system was of high priority within the organization and its schedule reflected this urgency. The entire schedule was expedited to less than half a year (159 calendar days) see table 2.

Table 2: Client Procurement Schedule.

Milestone Schedule				
#	Activity	Cumulative Calendar Days	Calender Days	Schedule
1	RFP Announcement	0	0	7/26/2017
2	Release RFP	14	14	8/9/2017
3	Educational Webinar (Online)	19	5	8/14/2017
4	Vendor pre-proposal educational meeting	34	15	8/29/2017
5	Submittal of proposals	53	19	9/17/2017
6	Rating of submittals / Shortlisting	54	1	9/18/2017
7	Interviews	55	1	9/19/2017
8	Identification of Best Value	57	2	9/21/2017
9	Notification sent to Best Value vendor	64	7	9/28/2017
10	Clarification kickoff meeting	116	52	11/26/2017
11	Final Clarification briefing	148	32	12/21/2017
12	Signing of contract	148	0	12/21/2017
13	Execution Phase	159	11	1/1/2018

For this research study, the client was identified to be in alignment with desired case study conditions. The client organization had little experience with the Best Value Approach. The BVA was introduced to the organization through a client sponsor, a newly appointed Finance Manager. The client sponsor was first exposed to BVA through the implementation of an ERP system in his previous employment, where the BVA was able to deliver the ERP project successfully (faster and significantly under budget). Under these conditions, the client, vendor pool and environment were identified to be aligned with a traditional ICT environment (environment unfamiliar with the BVA), as the client sponsor was the only individual in the organization familiar with the BVA and previous testing of the BVA within the area of the Gulf Region had not been done.

Client & Vendor Preparation

The Best Value Approach requires a change in paradigm on both the client and vendor side. As the project sponsor was the only individual on the client and vendor side familiar with the approach two educational sessions were held jointly with client and potential vendors. The first educational meeting was an online seminar with the focus of allowing all participants to better understand the BVA process and paradigm. The second meeting was an in-person pre-proposal educational meeting. The intent of this meeting was focused more on the client requirement and clarification required by competing vendors. The client invited and preselected all ERP experts within the Gulf Region to participate.

Client Requirement

The client's ERP program objective was identified to replace the client's independent business operation's current manual and semi-automated systems with a single system. The initial requirement of implementation given to the vendors was divided into two phases. Phase I included 6 core ERP functions as the requirement that would be bid for and Phase II included 14 future ERP functionality that were not included in the current requirement, see figure 1.

Phase I functions (6)	**Phase II not included in base bid (14)**	
Human Resources	**Human Resources**	**Finance and Accounting**
1. Personal Data	1. Benefits enrollment and administration	7. General ledger
2. Compensation	2. Recruitment	8. Accounts payable
3. Travel & Government relations	3. Talent management	9. Expense reporting
Finance and Accounting	**Other Functions**	10. Budgeting and forecasting
4. Timekeeping	4. Supply Chain	11. Asset management
5. Payroll	5. External Training and Decision Support Processes	12. Cash management/Treasury
6. Value added tax	6. Employee learning	13. Billing
		14. Accounts receivable

Figure 1: Initial Client Requirements.

The ERP system was expected to be fully operational within the client's identified conditions:

1. Saudi Arabian registered company (42 years).
2. Multiple sites within Saudi Arabia (internet connected).
3. Approximately 1,900 regular staff.
4. Currently running iSeries 400 and Maximo.
5. Existing manual processes in place for over 20 years.
6. 161 power users (amendment to RFP 8/29/17)
7. Price to include 5-year licensing of ERP technology.
8. Budget not provided.

After the 1st educational online seminar, due to vendor and internal client feedback, the client saw it would be beneficial for them to make a change in the requirement. The client increased the quantity of ERP functions and expanded their scope to include both Phase I and Phase II. This

changed the requirement from 6 included functions and 14 future functions to 41 included functions (see figure 2). This change in requirement was announced to the competing vendors during the 2nd educational pre-proposal meeting. During this meeting is was also clarified that the ERP system was to be offered as a cloud solution, with an on-premise solution as an optional service. Due to the vendor's submittal deadline being unchanged, the vendors had 14 days (4 working days excluding holiday and weekends) to incorporate these changes into their proposal.

Phase I Functions (11)

Human Resources

1. Personal Data
2. Wage changes
3. Transfers
4. Promotions, rewards
5. Compensation
6. Travel & Government relations
7. Vacation planning & other absences with approval workflow
8. Automated workflow

Finance and Accounting

9. Timekeeping
10. Payroll
11. Value added tax

Phase II Functions (30)

Human Resources

1. Employee performance
2. Benefits
3. Recruiting

Finance and Accounting

4. General ledger
5. Accounts payable
6. Expense reporting
7. Budgeting and forecasting
8. Asset management
9. Contracts
10. Cash management / treasury
11. Billing
12. Accounts receivable

Procurement and Supply Chain

13. Vendors, PR and PO, receiving
14. E-procurement
15. Catalog management
16. Supplier management
17. Strategic sourcing
18. Inventory/warehouse management
19. Facilities maintenance
20. Fleet management
21. Utility billing
22. Business licensing

Decisions Support Processes

23. Portal management
24. Data warehousing
25. Manager/employee self service
26. Performance scorecard
27. Ad-Hoc reporting
28. E-Trg (e.g. Ethics)

Training Processes

29. Learning Management
30. Learning Development

Figure 2: Updated Client Requirements.

Vendor Prioritization & Selection

The BVA PIPS process was run to prioritize and select the Best Value vendor with the following assumptions:

1. BVA was run by Best Value Expert Advisors, KSM Inc., as described in the RFP for the client.
2. BVA was run with the best interest of the client in mind.
3. Maximum information was collected from all vendors in the best interest of the client.
4. The client was attempting to identify the BV for the lowest cost based on 5 selection criteria with predetermined weighting
5. All vendors were given an equal opportunity to give the required information.

The client received six proposals to their RFP. The first issue identified was that the vendors' cost submittals needed additional clarification (see table 3). Although the client requirement now included both Phase I and Phase II, the vendors were still asked to provide a breakout of their cost by Phase I and Phase II. Vendor C was the only one to follow these instructions. Due to the available information, the client had a concern of the range of vendor pricing, ranging from less than a million to five million in total costs. The wide range made the client wonder if all the vendor's pricing included the same content. The range in project duration for some vendors also seemed suspicious. As the client was not an expert in the field, they found it to be in their best interest to keep all vendors in the competition but ask for clarification due to unclear/incomplete pricing.

Table 3: 1st Cost Submittals of Vendors.

	A	B	C	D	E	F
Total Cost Phase I and II ($M)	**$3.60**	N/A	**$0.91**	**$3.64**	**$2.48**	**$5.28**
Implementation	$1.23	N/A	$0.35	N/A	N/A	$0.60
License Fee (5 years)	$2.38	N/A	$0.56	N/A	N/A	$4.68
Total Duration (days)	N/A	N/A	112	1688	N/A	226
Phase I Cost ($M)	**$3.60**	**$0.22**	**$0.60**	**$1.88**	**$2.48**	**$5.28**
Implementation	$1.23	$0.22	$0.13	$0.93	N/A	$0.60
License Fee (5 years)	$2.38	N/A	$0.47	$0.95	N/A	$4.68
Phase 1 Duration (days)	270	N/A	55	120	257	226
Phase 2 Cost ($M)	**N/A**	**N/A**	**$0.31**	**$1.76**	**N/A**	**N/A**
Implementation			$0.22			
License Fee (5 years)			$0.09			
Phase 2 Duration (days)	**N/A**	**N/A**	**57**	**1568**	**N/A**	**N/A**

After clarification of vendor pricing, vendor B and D were nonresponsive in the request for pricing clarification and were excluded from the process. Vendor E confirmed their prices included Phase I and Phase II and Vendors A, C and F resubmitted their pricing to meet client's requirement (see table 4). After the pricing was clarified, there were four responsive bidders (A, C, E and F).

Table 4: Clarified Cost Submittals of Vendors.

	A	B	C	D	E	F
Total Cost Phase I and II ($M)	**$4.93**	N/A	**$2.64**	**N/A**	**$2.46**	**$6.05**
Implementation	$2.30	N/A	$0.35	N/A	$0.74	$1.05
License Fee (5 years)	$2.64	N/A	$2.29	N/A	$1.73	$5.00
Total Duration (days)	270	N/A	116	**N/A**	257	394
Phase I Cost ($M)	**$4.93**	**$0.22**	**$0.93**	**$1.88**	**$2.46**	**$5.60**
Implementation	$2.30	$0.22	$0.13	$0.93	$0.74	$0.60
License Fee (5 years)	$2.64	N/A	$0.80	$0.95	$1.73	$5.00
Phase 1 Duration (days)	270	N/A	74	120	257	226
Phase 2 Cost ($M)	**Included**	**N/A**	**$1.71**	**N/A**	**Included**	**$0.45**
Implementation		N/A	$0.22	N/A		N/A
License Fee (5 years)		N/A	$1.49	N/A		N/A
Phase 2 Duration (days)		**N/A**	**42**	**N/A**		**168**

Based on the project manager and technical lead interviews and three project capability submittals which evaluated the vendors level of expertise, risk assessment, and value-added options, the vendors were rated and prioritized based on the predefined weights of each criteria, see table 5 for results. The following observations were made:

1. Vendor E was prioritized as the Best Value for the lowest cost. Vendor E scored the highest within the four quality criteria and had the lowest cost, $157K lower than the 2nd prioritized vendor.
2. Vendor C was identified as 2nd prioritized. Their score is explained as they scored well in both the interview and submittals and had the 2nd lowest cost.

3. Vendor A was identified as the 3rd prioritized. There score is explained as they scored the highest in all 3 documents and scored well in their interview. However, their cost was second to highest, more than $2.5M more than the prioritized Best Value.
4. Vendor F was identified as the last prioritized. There score is explained as they failed to submit the three project capability documents which led to scoring neutral on all 3 documents. They also scored the lowest on their interview and came in as the highest price, more than $3.5M more than the prioritized Best Value.

Table 5: Prioritized Scoring of Vendors.

Total Score	**84**	**81**	**79**	**47**
Criteria (Normalized)	**E**	**C**	**A**	**F**
Level of Expertise rating (25)	14.1	20.8	25.0	12.6
Risk Assessment rating (10)	6.3	7.7	10.0	5.5
Value Added rating (5)	3.5	4.3	5.0	3.2
Interview rating PM (15)	15.0	10.5	11.2	6.2
Interview rating TL (15)	15.0	9.3	12.5	7.3
Cost (30)	30.0	28.2	15.1	12.3
Other Factors	**E**	**C**	**A**	**F**
Total Cost Phase I and II ($M)	**$2.46**	**$2.64**	**$4.93**	**$6.05**
Implementation	$0.74	$0.35	$2.30	$1.05
License Fee (5 years)	$1.73	$2.29	$2.64	$5.00
Total Duration (days)	257	116	270	394

*Weight of criteria is identified in parenthesis by criteria.

Before Vendor E was able to move into the clarification phase a reference check was done to confirm expertise and capability to deliver the project at the proposed price and time frame. As Vendor E did not provide any individual case studies with metrics to be verified, the client asked Vendor E to provide references that could be contacted for this reason. Three references were contacted and surveyed which confirmed the vendor as a high performing company and ERP system (see Table 6). However, the following observations were made:

1. References did not confirm the vendor's ability to implement the client's specific project in terms of scope and time, as they were not comparable projects.
2. If Vendor E proceeds into the clarification phase, in absence of references that confirm the vendor's ability to implement successfully, it will be critical to ensure a clear plan is provided before awarding the contract.
3. Vendor C has also provided high performance information to support them as the secondary vendor that will enter the clarification period if Vendor E fails to meet the requirements.

Table 6: Reference Check Results.

#	Customer Satisfaction (out of 10)	Average of 3 References (out of 10)
1	Satisfaction with Vendor E	7.8
2	Satisfaction with ERP System	7.7
3	Satisfaction with Training Program	8.0
4	Satisfaction with Vendor post-project support	7.7
5	# willing to demo system for client	3

Clarification Phase

Vendor E was identified as the prioritized Best Value vendor for the lowest cost and continued to the clarification phase. During the clarification phase the Best Value Expert advisors of the client assisted Vendor E in delivering the following clarification documents:

1. Finalized scope documents.
2. Cost Breakout and Price Schedule – The price schedule is an invoice schedule, identifying what major tasks the vendor will be invoicing for, and when. It should match the cost breakout, and milestone schedule.
3. Description of the end deliverable in terms of simplified metrics.
4. Detailed schedule – Including all activities required by the vendor, client and client stakeholders to perform the work.
5. Milestone schedule – A simplified milestone schedule based on the detailed schedule, written in terms of all stakeholders and major action items.
6. Client action item list – A simplified schedule based on detail and milestone schedule with a list of deliverables and actions required by the client.
7. Risk Management Plan (RMP) - document identifying risks that vendor does not control that could occur on this contract and assumptions the vendor has made that could cause risk if inaccurate. This plan will also have mitigation strategies. This plan includes concerns from the client and how the vendor will minimize those concerns.
8. Weekly Risk Report (WRR) that will track time and cost deviations.
9. PowerPoint presentation that describes the scope of the project in terms of cost, time, deliverables and how the deliverables acceptance will be decided.

Research Findings

Results and Analysis

The project was awarded with the following accomplishments:

1. A Best Value selection process was run utilizing the BVA PIPS process.
2. The client preselected the most qualified vendors in the Gulf Region capable of implementing an ERP platform.

3. In the short time span available, the vendors were competed, and the Best Value vendor was identified. The prioritized Best Value was the lowest cost, and the highest performance based on level of expertise, ability to identify and mitigate risk, value add and interview.
4. A clarification period was run, confirming that the vendor was the most capable, had a fair price and proposed a detailed schedule, milestone schedule, risk mitigation plan, scope document and weekly risk report that would track the project time and cost deviation.

In the analysis of the use of Best Value over traditional process the client participants which included the leads of all departments, were surveyed (7 individuals). The survey was on a scale from 1 to 10, with 10 representing that you were very satisfied/in complete agreement with the statement and 1 representing that you were very unsatisfied/in disagreement with the statement and 5 being neutral. Their responses identified the BV process to be faster, simpler, more efficient, better at minimizing client risk, and better at requiring pre-planning (see table 7). The measurable estimated benefits by the client include (See table 8):

1. The ability to procure without developing a complete scope requirement. This simplified the size of the scope requirement to 2 pages, a reduction of 48 pages (96% reduction) and saved 136 days (91% savings) and $500K dollars (100% cost saving).
2. The efficient, faster, and lowering costing identification of a Best Value vendor. This saved 136 days (50% reduction) in procurement and the reduction of 97 internal manhours (87% savings).
3. The delivery of a complete vendor proposal which the client understands and is satisfied with, that meets the client's requirement. The proposal is 30 days and $2.5M dollars less than expected (10%, 51% savings respectively), with a lower internal requirement from client project management from .8 FTE to .05 (94% reduction).

Table 7: Client Traditional vs Best Value Surveyed Results.

Vendor Proposal	**Best Value**	
Understand the vendor's proposal including the deliverables and schedule.	8.57	
Understand the time, actions, deliverables, and resources required from my department.	8.29	
Overall customer satisfaction and comfort level in hiring the vendor	9.43	
Process Survey Questions	**Traditional**	**Best Value**
The process minimizes the time it takes to deliver the project/service	5.5	9.0
The process forces the vendor to pre-plan, identify and minimize risks before the project begins.	5.8	8.9
The process is simple and easy to implement	6.5	8.3
The process is efficient (minimizes cost, time, and effort)	5.0	9.3
The process identifies the highest performing and lowest costing vendor	7.5	9.0
The process minimizes the risk to the client	6.8	8.9
Overall satisfaction with the selection and clarification process	6.3	9.4

Table 8: Client Traditional vs Best Value Estimated Results.

RFP Creation	**Traditional***	**Best Value****
Time to develop requirement statement	150 days	14 days
External Cost to develop requirement statement	$500K	$0
Size of scope requirement (pages)	50 pages	2 pages
Selection	**Traditional***	**Best Value****
Time to procure ERP project	270 days	134 days
# of people to rate and score vendors including submittals and interview	10	9
Client hours to rate and score vendors including submittals and interview (total / per person)	100 / 10 hrs	12.1 / 1.3 hrs
Vendor Proposal	**Traditional***	**Best Value****
Awarded duration of project	300 days	270 days
Awarded cost of project	$5 M	$ 2.46 M
Client PM estimated (FTE)	.8	.05

*Estimated. **Actual.

In answering the papers research question, the Best Value Approach was found to have been implemented successfully and capable to identify an ERP implementation expert. The BVA claims were confirmed with documented results to being simpler, quicker, lower costing, and capable to deliver a complete plan including detailed schedule, milestone schedule, and schedule that identifies all stakeholder activity.

Recommended Future Actions

The project was considered a success in selecting a Best Value expert, however, the project is not yet over and still must be executed. The Best Value Approach requires a change in paradigm both on the client and vendor side. During the selection of the vendor, a BVA expert advisor was used to hold both client and vendor accountable to this new paradigm. Without the assistance of the BVA expert advisor the project would have had many opportunities of reversion. The project will continue with the expert vendor executing their approved plan and following the BVA process which includes the Weekly Risk Reporting system. The greatest risk to the project moving forward is still the reversion of either client or vendor to the traditional paradigm. The following are observations of the BVA expert advisors:

1. The vendor may have difficulty in transforming from their traditional approach to be a Best Value vendor acting in the best interest of the client.
2. The client may have difficulty in their new role as the utilizer of the vendor's expertise. Client decision making, and direction of the vendor must be minimized.

3. The vendor may not understand how to use metrics to optimize ERP performance and identify the value of the implemented ERP system including the analysis needed to reflect this impact in the VA organization.
4. The vendor is new to and not accustomed to the effective use of the BVA's reporting tool (the Weekly Risk Report), vendor must be further mentored in their usage and content must be refined during the beginning of the execution phase.
5. The client may not know how to optimize their implemented ERP system due to decision making and traditional mode of operation. One example is the usage of the ERP system to automate all significant procurement activities.

Due to the existing risk of reversion, it is advised that Best Value advisors be maintained throughout the completion of the project to minimize and mitigate these risks.

References

Cutter Consortium. (2008) How agile projects measure up, … to you. Arlington, MA: Mah, M., Lunt, M.

Duren, J. and Doree, A. (2008) An evaluation of Performance Information Procurement System (PIPS), 3rd international public procurement conference proceedings 28(30) pp 923-946.

Kashiwagi, D. (2011). Case study: Best Value procurement/performance information procurement system development. Journal for the Advancement of Performance Information & Value, 3(1).

Kashiwagi, D. (2014). 2014 Best Value Standard. Performance Based Studies Research Group. Tempe, Az. Publisher: KSM Inc., 2014.

Kashiwagi, D., & Kashiwagi, I. (2014). The Best Value ICT Industry. Journal for the Advancement of Performance Information & Value, 6(1).

Kashiwagi, I. (2018). A Global Study on ICT Project Performance (or "Manuscript in preparation").

Kashiwagi, I., van Hes, S., Tschi, G. C., & Kashiwagi, D. (2015). The Cause of Collusion in the IT and Construction Industries. Journal for the Advancement of Performance Information & Value, 7(1).

Kashiwagi, J. (2013). Dissertation. "Factors of Success in Performance Information Procurement System / Performance Information Risk Management System." Delft University, Netherlands.

Legislative Assembly of the Northern Territory. (2014) Management of ICT Projects by Government Agencies. Northern Territory, Australia. National Library of Australia Cataloguing-in-Publication Data

Logemann N. & Kashiwagi, I. (2017). Professionals' Impressions Regarding the Saudi Arabian Procurement and Contracts System. Performance Information and Value, 51.

Project Management Institute. (2014, May) PMI certification statistics. PMI Today.

Public Administration Committee. (2011). Government and IT— "a recipe for rip-offs": Time for a new approach. Twelfth Report of Session, 12.

QSM Associates. (2009) The agile impact report: …enterprise. McLean, VA: n.d.

Rijt, J., Santema, S. (2013) The Best Value Approach in the Netherlands: a reflection on past, present, and future. Journal for advancement of performance information and value, 4 (2), 147-160.

Rivera, A. O. (2014). Impact of a Non-traditional Research Approach (Doctoral dissertation, Arizona State University).

Rivera, A., Le, N., Kashiwagi, J., & Kashiwagi, D. (2016). Identifying the Global Performance of the Construction Industry. Journal for the Advancement of Performance Information & Value, 8(2).

Scrum Alliance. (2013) The state of scrum: benchmarks and guidelines. Orlando, FL: Kim, D.

Standish Group. (2013). CHAOS Manifesto 2013. Boston, MA: The Standish Group International, Inc.

State of Hawaii PIPS Advisory Committee 2002, Report for Senate Concurrent Resolution No. 39 Requesting a Review of the Performance Information Procurement System (PIPS), Honolulu, HI: U.S. Government, Available from: http://hawaii.gov/dags/rpts/pips.pdf.

The House of Representatives of the Netherlands (2014) Conclusions and recommendations of the Dutch temporary committee on government ICT projects.

US Department of Commerce. (2011). Census 2010: final report to congress. (Final Report No. OIG-11-030-I). Washington, D.C.: U.S. OIG Office of Audit and Evaluation.

Best Value Approach in Public Procurement: Improving 'Best' through Enhanced Preparation Phase

Frank P. Steller
TU Delft
The Netherlands

The Best Value Approach (BVA) offers an innovative method to get the most out of Supplier-Customer Relationships (SCRs). This paper argues that the preparation phase should be enhanced when applying BVA in the context of public procurement. Literature on SCRs learns how successful relationships are governed bilaterally during execution. This literature also describes which processes are taking place prior to contracting. Here, the concepts of this literature are applied to analyses the specific public procurement context. The impact of this context is, that the tender process is governed unilaterally. Further, BVA - as applied in public procurement - is viewed through the lenses of the SCR literature. Although BVA partly leads to bilateral governance, the impact of the public procurement context remains. For practitioners wanting to improve BVA's effect in public procurement, the paper offers an enhancement of the approach. For theory building, the analysis leads to a further differentiation of the concept of governance. For regulators, it offers something to consider: focus on principles or rules?

Keywords: Best Value Approach, Buyer-Seller Relationship, Relationship Governance, Public Procurement.

Introduction

As a practitioner, the author has experienced that Supplier-Customer Relationships (SCRs) in public procurement not always bring both parties the intended result. This is even more disappointing, as parties went through a meticulous tender process as set by the leading principles of public procurement. The SCR literature discusses the ways parties work together, improve performance and achieve goals for their relationship. The central concept is that of governance, in this paper defined as: the actions parties take to control, influence, or regulate the policy and affairs of a SCR (based on Oxford's dictionary). Literature has reached a consensus, that best performing SCRs attain their results by combining contractual and relational governance (Cao & Lumineau, 2015). Contractual governance is defined as: "the extent to which roles, obligations, responsibilities, contingency adaptation, and legal penalty are specified or well-detailed in formal agreements" (Cao and Lumineau, 2015), and relational governance as: "the extent to which the relationship is governed by trust, flexibility, solidarity, information exchange, fairness, and informal rules and procedures" (Cao and Lumineau, 2015).

Such governance is preceded by pre-contractual mechanisms as described in Social Exchange Theory (SET), Relational Exchange Theory (RET), and Transaction Cost Economics (TCE). Prior to contract signing, parties use the following mechanisms to lay the foundations for relational and contractual governance. Repetitive negotiations consisting of formal bargaining and informal social-psychological processes of sense-making lead to joint expectations of risk and trust (Ring & Van de Ven, 1994); parties gradually develop relational norms (I. R. Macneil, 1980), and trust and commitment (Morgan & Hunt, 1994), together leading to relational

governance (Dwyer, Schurr, & Oh, 1987; Dyer & Singh, 1998; Heide & John, 1992). Contractual governance is developed through "offering safeguards by aligning incentives …or expanding a trading relation from unilateral to bilateral exchange through the concerted effort of reciprocity, thereby to effect an equilibration of trading hazards" (Williamson, 1985).

From Information Measurement Theory (Kashiwagi & Slater, 2003), the Best Value Approach (BVA) is developed to attain intended SCR results through specific interactions, starting in the pre-contractual phase (Kashiwagi, 2015). The Best Value Approach aims to enhance SCR's value by splitting responsibilities regarding substance (the goods, services, or works transacted in the SCR) between customer and supplier. Even before contracting, the supplier focuses on developing and delivering the solution for a outcome that the customer has set as its SCR goal. Therefore, parties need to interact to truly understand each other's goals, processes, needs, organization (Bergema, 2016). This approach has been adapted for application in public procurement in the Netherlands (Rijt, Witteveen, Santema, 2016). BVA has shown its positive effects in ample cases, industries, and geographies (Rijt, Santema, 2012; Rijt, Santema, 2013); both in private as in public procurement.

However, literature does not tell us whether these pre-contractual SCR processes emerge in public procurement as well. Nor do we understand BVA's success in terms of SET, RET, or TCE. From this scholarly perspective, the author suggests a major oversight in the practice of public procurement. Pre-contractually, the interaction between customer and each of the aspirant suppliers is disabled, invoked by the customer's dominance in executing a fair, equitable, transparent, and non-discriminatory contract awarding, and by the risk of a supplier using its power to object to customer's decisions, potentially stopping the tender (hindrance power). This could be a cause for the often-disappointing results during contract execution. Recently, Tulling (2018) analyzed the conflicts during execution of Best Value projects. Partly these can be traced to insufficient understanding between parties, starting in earlier phases. Further, to understand whether BVA can resolve this cause, BVA is analyzed in terms of SET, RET, and TCE. On the substance level BVA does result in pre-contractual interaction. However, on the process level, the cause is not yet remedied by the current version of BVA: it does not change the way parties behave in public procurement. Finally based on this analysis, the author develops an enhancement to the practice of public procurement, which together with applying BVA could resolve the cause. By introducing dialogue even earlier and extending it to the process level, pre-contractual mechanisms are pre-empted. Such dialogue can be compliant to the leading principles of public procurement. And such dialogue enables parties to experience each other as expert in their field. This will improve adherence to Best Value principles in all SCR phases.

Research Question & Method

This conceptual paper is confined to the research question: How can the Best Value Approach further improve the value of SCRs in public procurement? The answer to this question is sought through three steps. First, understanding how SCRs are formed in public procurement, and identifying differences in the processes and initial conditions compared to literature. Second, understanding BVA in the public procurement context in governance terms. Third, designing processes to resolve deficiencies found.

Research on the emergence and development of SCRs within public procurement - which have been established using BVA - has not been identified. Therefor this paper is based on exploratory research, solely based on literature research and analysis. The study takes an organizational and dyadic perspective, with the relationship as unit of analysis, and is limited to new SCRs (no joint past experiences between parties) in the public procurement context. This context is further called the Regulated Tender Environment (RTE). The analysis of the RTE is based on the Dutch regulations (as derived from European directives), combined with the author's experiences as practitioner. For the analysis of the pre-contractual processes and initial conditions, the theoretical lenses of SET, RET and TCE are applied as most SCR studies are based on a combination of these fields (Cao & Lumineau, 2015). BVA in RTE is analyzed using the same theoretical lenses. Based on the insights derived, additional and RTE-compliant process steps are identified, to enable the initial conditions and pre-contractual processes as described in literature for non-RTE context. Each of the research steps is dealt with in a separate section, together leading to a conclusion and discussion.

Pre-Contractual SCR Processes Within RTE

In this section the phases and pre-contractual activities in a SCR within RTE are described. Further, literature on SCR is used to analyses the processes and initial conditions within RTE. Thus, causes are identified, which prevent SCRs in RTE to develop as described in literature. Finally, the analysis leads to a differentiation of the concept of governance not yet found in literature.

RTE Essentials

The public procurement market is relevant for potential suppliers because of its size: "worth an estimated US$ 1.7 trillion annually*"* (World Trade Organization, 2016), for customers to maximize their satisfaction and performance with their SCRs, for public policy makers to pursue their policies, and for scholars to study the RTE effect. The EU directives state in their considerations the leading principles: equal treatment, non-discrimination, mutual recognition, proportionality, and transparency. These are to be upheld by the 'contracting entity' (customer organization) towards each and between all suppliers. Further, several requirements and procedural options are given. In total, the regulations c.a. encompasses approx. 500 pages. The Regulated Tender Environment (RTE) and non-RTE differ. Whereas there is just a pre-contractual and an execution phase in non-regulated environments, in RTE the pre-contractual period is strictly split into pre-tender, tender, and contracting phases. During the tender phase, both the RTE principles and the detailed regulations apply. During all other phases of the SCR within RTE, the principles (continue to) apply. See Figure 1.

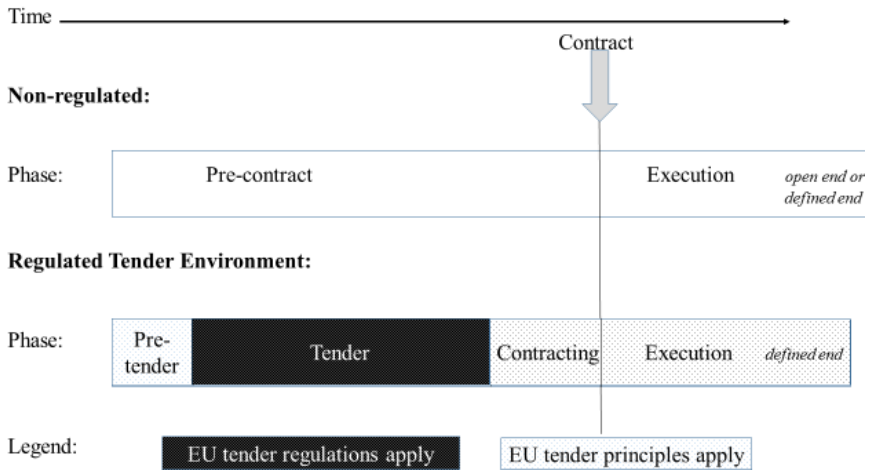


Figure 1: SCR phases in non-regulated and in Regulated Tender Environment (RTE).

Further differences are the either open or defined end (in non-RTE) versus the always defined end of the SCR in RTE, and the activity-split: whereas in non-RTE there is pre-dominantly joint activity (Figure 2), within RTE there is no joint activity.

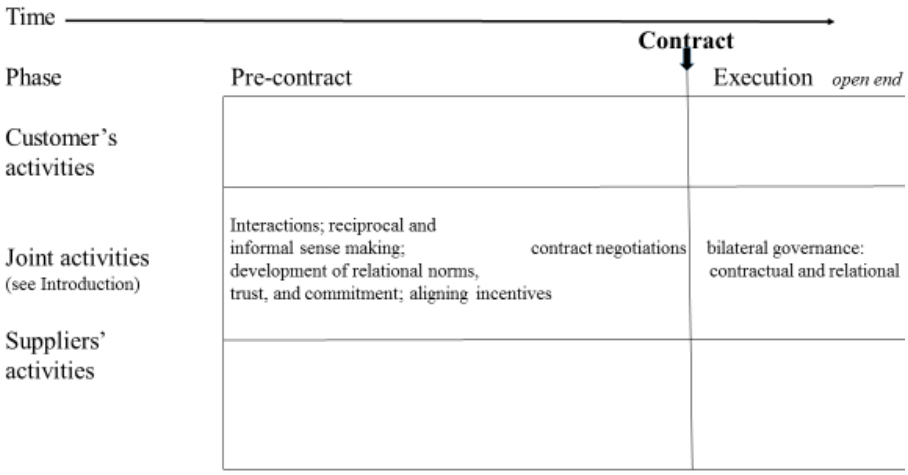


Figure 2: Customer's, suppliers', and joint activities in non-regulated SCRs.

In the RTE, tendering is regulated: communication is formal "all communication and information exchange under this Directive […] are performed using electronic means of communication" (art.40.1, directive 2014/25/EU), interaction is limited if happening at all (Telgen, Harland, & Knight, 2006), and joint activity seems prohibited. Within these formal requirements and on top of the written communications between parties during the tender, additional contact moments with oral communication may be used, if these are in line with the leading principles of the EU directives. E.g. with each of the parties to the procedure, separately. Further, the tender phase is split in episodes for notification, supplier assessment, solution assessment and awarding (see Figure 3). In some procedures supplier and solution assessment are combined and form one episode.

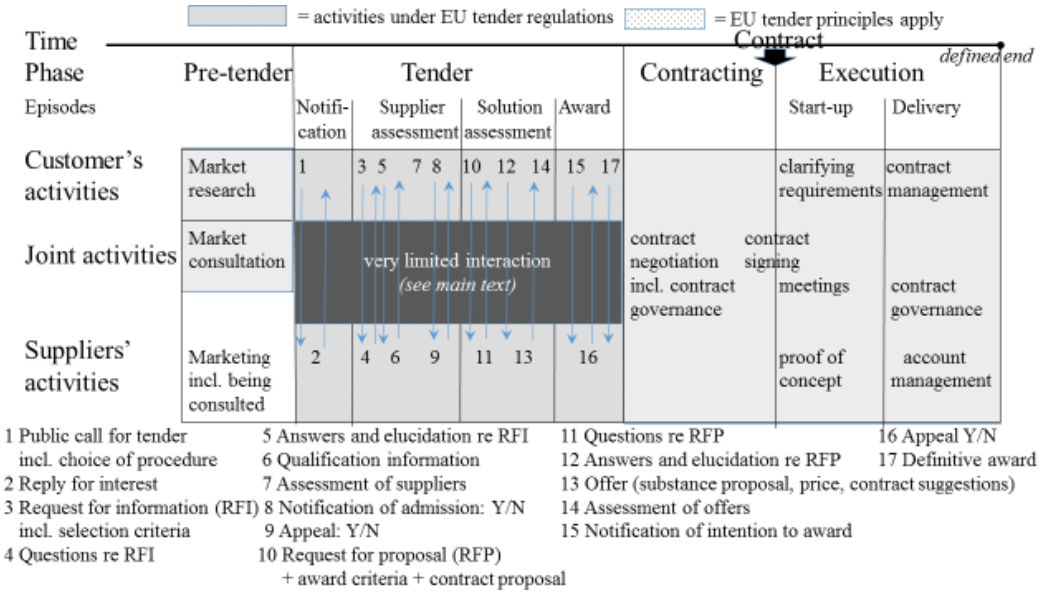


Figure 3: Customer's, suppliers', and joint activities in SCRs within RTE.

Activities 9 and 16 signify that each supplier can decide to appeal the customer's assessment and selection decision. Appeal constitutes a supplier's use of its hindrance power under RTE. Either the appeal is resolved between parties, if not the supplier can call upon the court to rule.

SCR Governance Within RTE

Introduction

Despite the extensive coverage of inter-organizational governance (Cao & Lumineau, 2015; Clauß, 2013), the forming of relationships under public procurement regulations is largely unknown, as is the development of governing these relationships. "The literature reports sparse research on the nature of government buying or how commercial firms can successfully market to the government" (Wang & Bunn, 2004, p. 85). Specifically, literature research shows two knowledge gaps regarding public procurement. First, the key conditions for contractual and relational governance in this environment are not met. Second, customers in the RTE and their representatives do not naturally achieve the necessary conditions for applying the bilateral processes. These customers are monopolies, either as governments or as 'special sector companies'. For the latter a special EU directive is in force because of *"*the closed nature of the markets in which the entities in those sectors operate, due to the existence of special or exclusive rights granted by the Member States*"* (consideration 1 of 2014/25/EU, European Council, 2014). In summary, although relationship governance in general is well studied, such is not the case for relationships under public procurement regulations. Therefore, the governance of SCR within RTE is analyzed using various theories.

Theory Based Analysis

This section analyses RTE through three theoretical lenses, to establish whether the contractual and relational governance necessary for successful SCRs can develop. The theoretical perspectives (SET, RET, and TCE) each discuss various processes and how these processes result in forms of governance during the execution phase of the SCR. This section's analysis focusses on these processes. First, the SET perspective is used: the attitude and behavior of

parties towards each other is analyzed and translated into their effect on the pre-contractual processes. Then, the RTE effect is analyzed in terms of Relational Exchange Theory (RET). Finally, the TCE perspective is applied. Using the latter theoretical lens, it is argued there is governance in RTE tender phase, which is being analyzed as well.

SET Analysis

Social Exchange Theory views a business transaction as a two-sided, mutually dependent process. In RTE, the contact setting between parties entering into a SCR is formal: the default method of communication is in writing, including reports of personal contacts between representatives of these parties. Further, the contracting entity can be held accountable for their choices and conduct. Such setting does not invite parties – even though such is permitted - to have "informal exchange of information" (Blau, 1964). Any action which could be seen as "furnishing benefits to the others" (Blau, 1964, p.16), is not in line with the leading principles of public procurement. This results for both parties in an abnormal setting: as if normal social interaction and reciprocation are forbidden. This disables the building of relational governance elements like trust, solidarity, and the use of informal rules and procedures, both for representatives from the customer as well as those from the supplier organization.

Moreover, given that in the EU, contracting parties chose the 'open' or 'restricted' procedure in 83% of the cases, the contacts between parties during the tender are in most cases in writing only, restricted to a public call for tender, submission of tenders, publication of award (see Fig. 3). This comes from the buyer's point of view close to 'discreteness' as described by Macneil (1980): "ignoring the identity of the other parties". Such indifference on the customer's part can hardly be working towards relational governance. Because of the leading principles the written supplier's questions (activities 4 and 11 in Figure 3) are anonymized before being answered by the assessors. So even supplier's (in)activity in the Q/A cannot be considered in the assessments. From the seller's point of view there is no opportunity whatsoever to initiate additional contact - let alone interaction - during the tender. Concluding, given the formal setting and default practice by contracting entities during the tender phase in public procurement the social interaction is very limited. Therefor preparatory processes for establishing relational governance cannot/do not take place during the tender phase.

RET Analysis

Relational Exchange Theory views contracts being based on contract and relational norms. The RTE tender situation is now analyzed using the norms Macneil (1980) has developed. Most of these will be dealt with separately, although they should all be seen in their entirety. Only those norms which are obviously already important in the beginning of the SCR are discussed. These are discussed in their basic meaning (as 'common contract norm'), and - where applicable - in their intensified way as relational norm: "the behavior that does occur in relations, must occur if relations are to continue, and hence ought to occur so long as their continuance is valued" (Macneil, 1980, p. 64).

Contractual solidarity - "the norm of holding exchanges together" (Macneil, 1980, p. 52) - is based on "a complex web of interdependence created by the relation itself" (Macneil, 1980, p.23). The intensified version is: preservation of the relation becomes the norm. Such solidarity can only emerge and develop by creating interdependency, as felt by both parties. During the

tender phase such is not the case, as the dependency is asymmetric: at any time, the contracting entity can abort the procedure without cause and compensation, whereas the suppliers must submit an unconditional and irrevocable offer. Only frequent interaction could lead to safeguards balancing the asymmetry. Given the basic tender modus as described, such is not the case. Mutuality: "this norm calls for a mutual perception of benefit, for some kind of evenness*"* (p. 44). Macneil concludes without it, the transaction will be stopped. Such mutual perception of benefit cannot come about without proper interaction between parties. Flexibility: "ongoing contractual relations must incorporate principles of flexibility within the relations (…) or it breaks apart under the pressure of change" (p. 50-51). Macneil describes a necessary "constant two-way flow of information, of consultation, advice, admonition, and adjustment in the various terms of the relation" (p. 51). During the tender process described, such is not taking place. Creation and restraint of power: "without shifts in power, (…) without restraint from absolute power the other norms would be rendered inoperative" (p. 56-57). The tender process as described is making use of absolute power.

Therefore, the tender situation as described is not warranting the development of relational norms necessary according to RET for 'modern contractual relations'. Further to Macneil, it is analyzed whether such tender qualifies as a discrete transaction. Absent the norm of contractual solidarity, the contract resembles a discrete transaction, from the part of the contracting entity: "separating the transaction from all else between parties" (Macneil, 1980, p. 60). Further discreteness requires "ignoring the identity of parties to a transaction, ...strictly limiting the sources of communication, ...planning and consent should occur only through formal, specific communication" (p. 61). It seems that the EU directives and their conversion into Dutch law do exactly that. Macneil concludes that rules of bureaucracies to regulate in detail are "an effort aimed at presentation and discreteness, and everybody knows it will not work" (p. 77). On top of that, the resemblance of discrete transaction is only from the buyer's perspective. By defining a "discrete transaction where each party is free to go ahead with a deal or not" (p. 26) Macneil makes equivalence between contracting entity and supplier a necessary condition. Such is not the case in a RTE tender. Concluding, according to Relational Exchange Theory the tender procedure in the RTE is deficient in many ways as start for a stable SCR as the necessary relational norms are not being developed.

TCE Analysis

Transaction Cost Economics "assigns transactions … to governance structures … in a discriminating way (Williamson, 1985a, p.18) . In non-RTE situations, the pre-contractual process is not specified (Figure 1), therefore - in line with Williamson (1985) – this paper views the process there, as led by market governance. During execution the SCR is subject to contractual governance, 'unified governance' being excluded: the transaction is not "removed from the market and organized within one firm, subject to an authority relation (vertical integration)" (Williamson, 1985). Unified governance is by nature all-encompassing and irreversibly unilateral. Within RTE, however, during the tender phase there is clearly a specified process. Following analysis therefore focusses on the type of governance being employed during tender, and its effect for subsequent phases.

TCE argues that under conditions of bounded rationality and opportunism serious (contractual) difficulties arise, and "governance structures … are evidently needed" (Williamson, 1985a,

p.63). For the tender situation, these conditions apply to both the contracting entity (customer-to-be) and the supplier-to-be: the obligation to tender and the long-term nature of the contract result for both parties in a situation of bounded rationality, as for neither party all potential situations are foreseeable. For each party opportunism by the other is present as well: for the supplier, it is uncertain whether the contracting entity will pursue the tender; for the contracting entity, it is uncertain whether the supplier's offers will be reasonable. TCE further argues that the extent of asset specificity determines which governance should be applied.

In case no transaction specific investments have to be made, TCE argues governance to be "discrete market contracting" (Williamson, 1985a, p.34). On the one hand this could be true from the perspective of the contracting entity: "parties have no continuing interest in the identity of one another" (Williamson, 1985a, p.31) as their interpretation of applying the principles of equal treatment and non-discrimination. On the other hand, however, such cannot be the case: if the customer's need is "for supplies quoted and purchased on a commodity market" no call for tender is required (EU 2014/25, art. 50g). As the contracting entity chooses to publish a call for tender, its need is more specific than can be bought on such a "fully contestable" (Williamson, 1985a, p.31) market (for services such markets are non-existent). From the supplier's perspective there are always transaction specific investments in the form of opportunity cost in submitting a tender. The offer must be unconditional and irrevocable and relates to a large transaction (for which a public tender is prescribed) or a stream of transactions during several years, thus sufficient production capacity has to be reserved for timely delivery; and compliance to other elements of the tender procedure have their cost as well. This is seen as transaction specific investment by the supplier. Thus, for both parties' market governance does not pertain.

Two alternatives remain: either the contracting entity offers safeguards, or it does not. This also applies when additional transaction specific investments are called for in the tender due to the nature of the need. If safeguards would be offered e.g. "to support and signal continuity through reciprocity, [TCE views this as] expanding the relation from unilateral to bilateral exchange" (Williamson, 1985a, p. 34). Given the procedure as described, no safeguards are being offered. According to TCE, normal bilateral governance does not apply during the tender situation under public procurement regulations. Without safeguards suppliers will offer a price higher than would be offered given safeguards. "Such transactions are apt to be unstable contractually" (Williamson, 1985a, p 34). This is not in line with the time and effort the contracting entity has invested so far, and the (mostly) long term nature of the contract on offer.

Finally, given the call for competition which should be fully transparent, it is not the intention of the contracting entity (nor presumably of the suppliers) to enter a relation where transactions are removed from the market and organized within one firm (and the other party dissolves). Therefore, unified governance is not applicable. As no contract is yet agreed upon, contractual governance in the strict sense cannot be present in this phase. Based on TCE market, unified, and normal bilateral governance are excluded options for the tender phase in RTE, no reciprocal safeguards are given. The process during tender resembles unified governance, both the substance and the process are set unilaterally: although both parties remain autonomous, their independency is fully asymmetrical. One party (the contracting entity) is calling the shots; the suppliers being nearly fully dependent in this process. On the scale of full autonomy for both to autonomy for one and none for the other, the tender process is one between these extremes, yet

near the latter end. The autonomous party is clearly the customer-to-be. Yet, the customer's actions to control, influence, or regulate the policy and affairs of the suppliers are regulated. Therefor - using TCE - such governance is best described as 'customer-led regulated unilateral governance'. Whether the unilateral aspect is later, during in the execution phase transited into a bilateral one as known in non-RTE situations, is not yet described in literature.

Theory Based Findings
Further to the analysis by theory, RET and TCE each supports the arguments of the other theory and of SET. E.g. Williamson points to the necessity of concerted use of reciprocity in establishing safeguards (Williamson, 1985a, p.34), "good faith and trust are vital … in the basic substantive workings of contractual relations" (Macneil, 1980, p.68), and "transaction cost economics should often be used in addition to, rather than to the exclusion of alternative approaches" (Williamson, 1985, p.18)

Based on an analysis of the behavior by parties in public procurement during the tender – using SET and RET – the processes which lay the foundations for relational and contractual governance are not in force, and – using TCE – all governance options as offered by literature seem not to be applicable as contact between parties is regulated. In our research we conclude that unilateral governance is likely, and an extraordinary governance for the tender process is used. It is positioned near the hierarchy end, where the customer's organization has near-full autonomy. It is called customer-led regulated unilateral governance.

SCR literature builds upon the cooperative premise of Ring & Van de Ven (1994), where parties actively and reciprocally regard their relational expectations as similar. Based upon the analysis above, such is not the case at the start of a RTE tender. In RTE nor the initial condition, nor the processes are in place which in non-RTE lead to a bilateral contractual and relational governance. Yet, also within RTE parties to a SCR intend to develop a successful relationship. The next section investigates whether BVA can enable this.

Best Value Approach Viewed Through the Governance Lens

This section describes the BVA phases, episodes, and activities as they are performed within RTE. Further, the Best Value Approach is viewed through the governance lens. This leads to a further differentiation of the governance concept.

BVA's Essentials per Phase

BVA offers an approach and method to improve the value of Supplier-Customer Relationships. The result of BVA is measured against the goals set by the customer (Kashiwagi, 2015). As in the Supplier-Customer Relationship literature, BVA distinguishes a number of phases, and divides activities in those for the customer, the (potential) supplier(s), and for both (Rijt, van der J, & Santema, 2013). The BVA phases within RTE are: I Preparation (up to the public call for competition, yet including the explanatory meeting on Best Value), II Assessment (selecting qualified suppliers and best ranked supplier), III Clarification (detailed assessment of best

solution, contracting and definitive awarding of the contract), IV Execution (Rijt, Witteveen, Santema, 2016). See Figure 4.

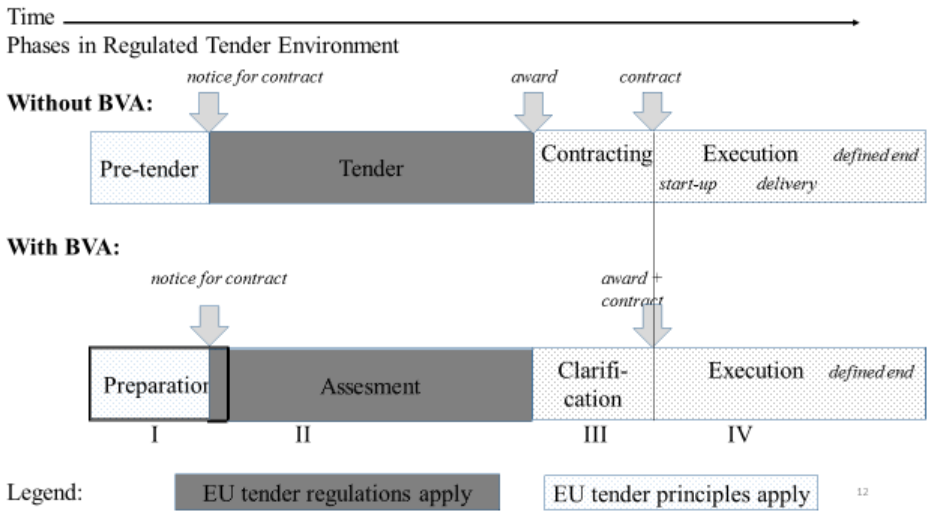


Figure 4: SCR phases in Regulated Tender Environment (RTE) without and with BVA.

An essential difference is that in BVA the award and contracting are after the clarification phase, whereas in non-BVA clarification takes place during start-up, after contracting. For all essential BVA activities per phase, as performed by each party or together, see Figure 5. In the RTE, the BVA Preparation activities of inviting potential suppliers and having an explanatory meeting regarding the aim and procedure of the tender are after the public notice for contract, therefor the Regulations apply.

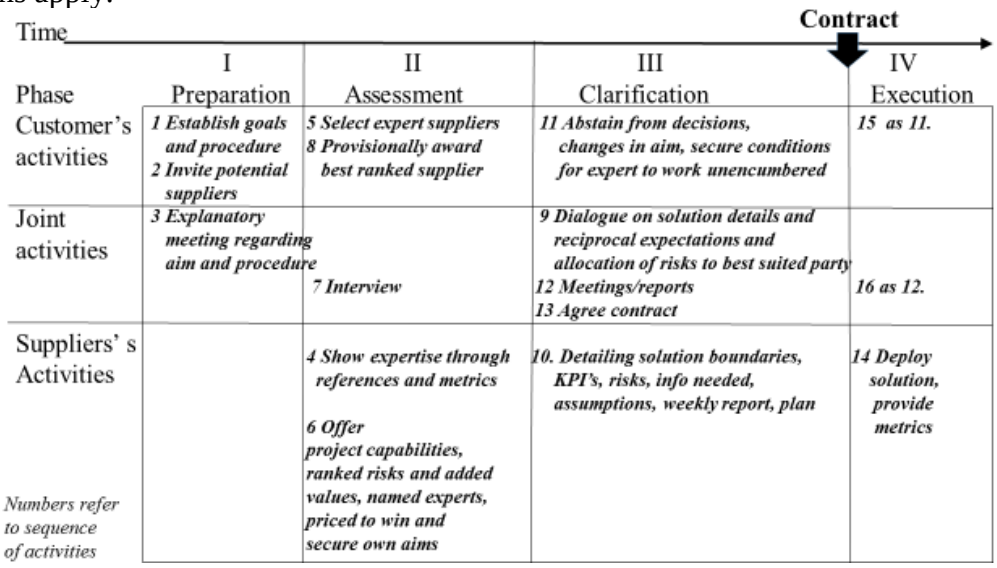


Figure 5: Essential activities of the Best Value Approach per phase.

BVA in Governance Terms

After the activities, now the governance is analyzed. Governance as employed by the customer, the supplier, or jointly in the BVA phases. The result is shown in Figure 6, each letter of which is explained below. The letters specify different types of governance. The alphabetical order is in

line with the activity sequence (numbers in Figure 5). In BVA, during preparation, the customer is in charge: setting the goals for the SCR (activity 1, Figure 5). Based on the definitions (see Introduction) this is viewed as (part of) 'contractual governance', unilaterally performed by the customer. The goal primarily concerns the substance of the SCR: the services rendered, goods, and/or works being delivered. The goal can be specified at three levels. Strategic: what the outcome for the customer's organization (or even its customers) should be; tactical: how the substance should function for the customer's organization (functional specification); operational: how the substance is to be produced by the supplier to function in the customer's processes.

BVA prescribes, substance should solely be specified at the strategic level. This introduces a new phenomenon: 'strategic contractual governance' (A in Figure 6). This governance is continued by the customer during all phases (A, C, F1, and K1 in Figure 6). F1 and F2, K1 and K2 signify the bilateral nature of the contractual governance. Relational governance is by nature bilateral. At the same time, in BVA the customer is setting the procedure for the assessment phase: e.g. choosing BVA and setting the minimum requirements for selection, awarding criteria, and their weights (B, Figure 6). This activity is not related to the substance of the SCR, only to the process of forming the relationship. Like this phenomenon in RTE, it is performed unilaterally, and is called process governance; but is not regulated (unless the SCR is tender within the RTE, see next section). This process governance is continued by the customer during the assessment phase (D, Figure 6). However, during the latter phase there is also room for relational governance (E, Figure 6), or at least interaction processes necessary for sense making mechanisms elucidated above. Staging the explanatory meeting (3, Figure 5), the interview (7, Figure 5), and utilizing it for a dialogue (9, Figure 5) are proof for that.

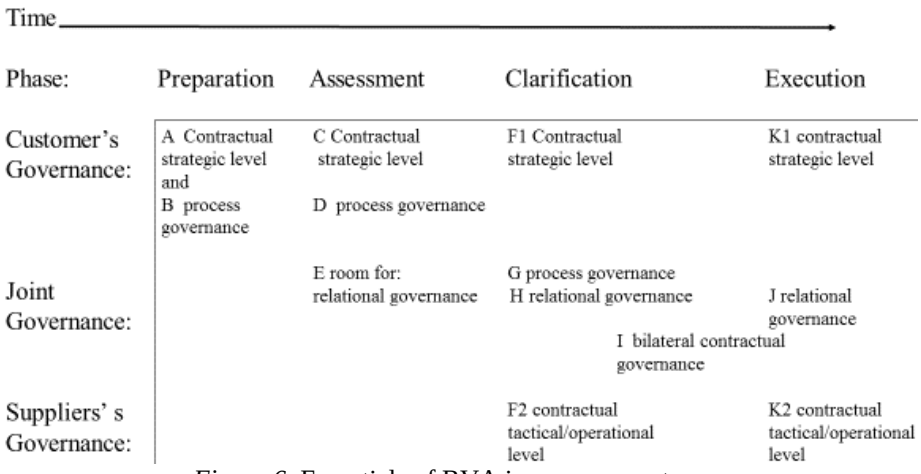


Figure 6: Essentials of BVA in governance terms.

In the clarification phase, BVA prescribes that after the selection of the best value solution the governance changes. It is the supplier who also takes on contractual governance - be it at the tactical and operational level – by explaining and clarifying the solution, proposing the key-performance indicators, and drafting the contract (F2, Figure 6). BVA introduces a split in contractual substance governance: simultaneously performing both strategic and tactical/operational contractual governance, each unilaterally, and by different parties. (F1 and F2, Figure 6). During this phase, process governance continues and changes as well. Now both parties take an active role (e.g. the supplier is setting the agenda): process governance becomes

bilateral (G, Figure 6). Further, based on the joint activities during assessment, and the joint process governance parties develop relational governance (bilateral, by nature) (H, Figure 6): parties interact frequently (weekly reports, meetings), in dialogue, and regarding many subjects (see activities 9, 10,11 and 12, Figure 6). This phase ends by jointly signing the contract (activity 13, figure 6). At the same time bilateral contractual governance sets in (I, Figure 6), replacing process governance. All the while the relational governance can (and should, see Cao and Lumineau, 2015) be build and continued from here onwards (J, Figure 6).

In the execution phase the customer's governance remains at the strategic contractual level (focusing on its goals and abstaining from 'Manage, Direct and Control') while the supplier's contractual governance remains at the tactical /operational: delivering what has been agreed. This paper has not analyzed how the governance operates during major changes. It is assumed this is being dealt with through the dynamics in bilateral contractual and relational governance (Huber & Fisher, 2013).

In summary, BVA in governance terms knows all the elements of governance, but in a different configuration than often found. First, BVA splits the contractual substance governance in strategic (by the customer) and tactical/operational (by the supplier). Second, BVA uses process governance, changing from unilateral in the assessment phase to bilateral during clarification. Third, BVA - in the transition from clarification to execution – replaces this by bilateral contractual governance, as process and substance governance are combined, based on the negotiated contract. Fourth, BVA promotes interaction and reciprocal sense making in all phases and enables relational governance as from clarification phase.

Concluding the first step of the analysis, BVA prepares the conditions for maximizing SCR value and improving satisfaction for both parties during execution. Because, BVA promotes adherence and performance to strategic goals; BVA employs bilateral contractual and relational governance; BVA promotes early exchange of expectations, preventing misaligned expectations and early SCR dissolution (Harmeling & Palmatier, 2015). The next section analyses the BVA governance when applied in RTE.

BVA Governance in the RTE

To deduce the governance as applied in the RTE, following steps are undertaken. First, the activities as performed in BVA within RTE are laid down. To this end, the essentials of BVA (Figure 5) are combined with the activities as normally performed within RTE (Figure 3). See Appendix I for details. Based on this, the governance as applied for each phase is determined. For the pre-tender and tender phases, there is no difference within RTE whether BVA is applied or not. In all cases the customer performs unilateral contractual governance, both related to substance and to process. Specifically, within BVA, the substance is only set at the strategic level, and the process is according to BVA format. Even though formal interactions are allowed, the informal, recurrent interactions and development of relational norms are not. Therefore, in all cases there is no reciprocal sense making, no mechanisms leading to relational governance are taking place during Assessment. This leads to the following constellation of governance of BVA within RTE, see Figure 7.

Concluding, also when applying BVA in RTE the interaction between customer and each of the aspirant suppliers is disabled during tender. As in all RTE tenders, also when using BVA, this is invoked by the customer's dominance in executing a fair, equitable, transparent, and non-discriminatory contract awarding, and by the risk of a supplier using its 'hindrance power' to object to the decision and delay the process. In the next section, interventions are proposed which could alleviate this.

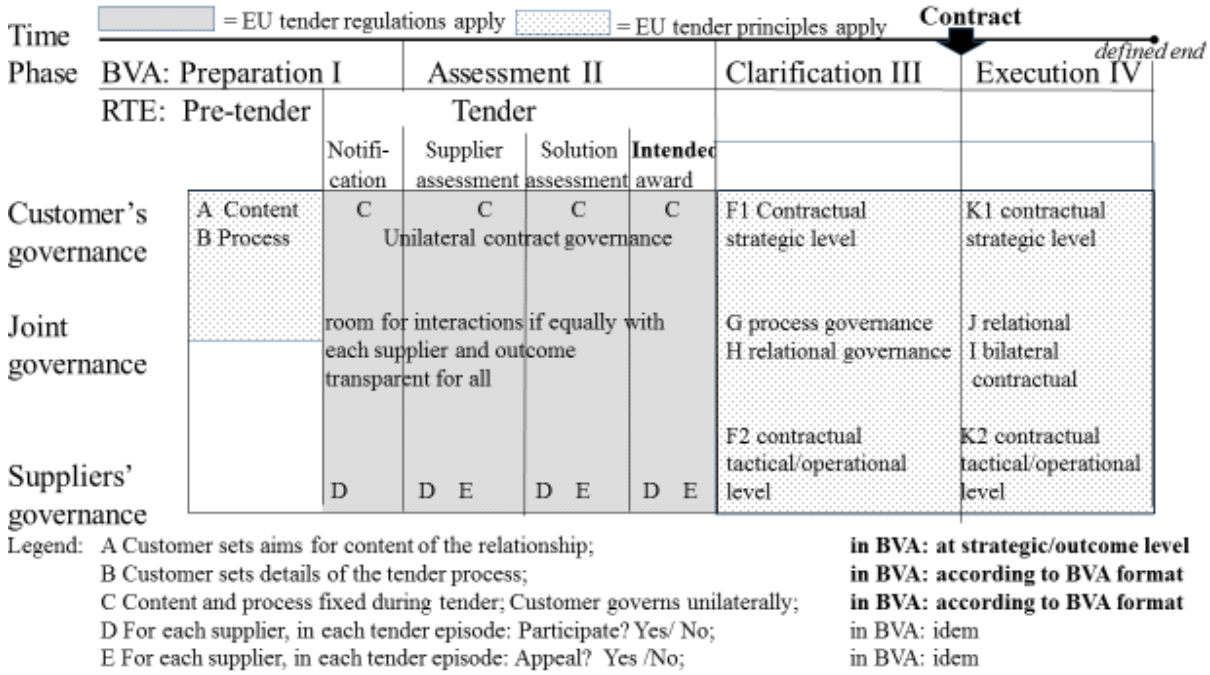


Figure 7: BVA governance within RTE.

Enhancing BVA's Preparatory Phase

In this section a regulations compliant trigger is developed for early and fully enabled interaction for an RTE tender. This is positioned in the pre-tender or preparation phase. Although the regulatory principles apply, no formal regulations are inhibiting the chosen formats. In this setting, parties can choose for an open exchange of suppliers' tender experiences and customer's tender expertise. This can prevent negatively contrasting expectations (Harmeling & Palmatier, 2015). The starting condition of the tender phase is changed. Starting from more aligned expectations, the tender phase could also be used for assimilation, establishing relationship building mechanisms like demonstration, negotiation and learning (Harmeling & Palmatier, 2015). After all, the EU directives do not prescribe how process governance is shaped and performed, a fortiori: who governs. Therefore, a bilateral process governance would be RTE compliant. In such case, apart from using the tender phase for selecting the winning supplier cum solution, bilateral mechanisms would be practiced. This certainly improves the starting condition for the later phases.

Using TCE, such bilateral process governance increases (joint) rationality and reduces opportunism. From a SET point of view, 'informal exchange of information' is possible, if the

benefits are furnished to all others. Viewed through the RET lens, parties would establish norms of contractual solidarity, mutuality, flexibility, and creation and restraint of power. For this, however, the bilateral process governance should be of a principle-based kind. If a ruled based attitude by either party would prevail, such mechanisms could not flourish: the shadow of future use of either party's power (for the customer: to abort the procedure, for the supplier: to appeal) prevents assimilation and the process would fall back to the default situation.

Addition to BVA's Preparatory Phase

How can the unilateral starting condition of the tender phase in the RTE be altered when applying BVA? This is to be the result of actions taken in the preparatory phase. The customer performs (in most cases) market research and sometimes market consultation during this phase (Figure 1). However, as market consultation in RTE is hardly used (TED structured dataset, 2015), no metrics on its effect are available. In that case the leading principles of the directives apply, foreshadowing the regulations during the tender phase. During market consultation there can be actual (face-to-face) interaction with potential suppliers (and other contracting entities), whereas market research is purely desk research.

Market consultation and research are predominantly being used to learn about the market for the services, goods and/or works intended to be contracted: substance focused. However, market consultation can also be used to be better informed about suppliers' expertise, experiences, and expectations regarding the RTE tender process, and RTE tender expertise of other contracting entities. Preparing for RTE tender, customers can use the official means for notifying their 'call for competition' (in the EU the TED website, for the Netherlands TenderNed) to arouse early interest and contact potential suppliers for market consultation. If in such a 'notice of market consultation' the procedure for this consultation is transparent and follows the other leading principles, the customer is RTE compliant when having a dialogue and even in-depth discussions with each interested supplier separately. During the tender phase, the lessons learnt regarding the procedure should become transparent in the request for information incl. selection criteria and request for proposal incl. award criteria. For the proposed steps to be taken in such an enhanced preparatory phase, by the customer, each interested supplier, and each customer-supplier combination, see Figure 8.

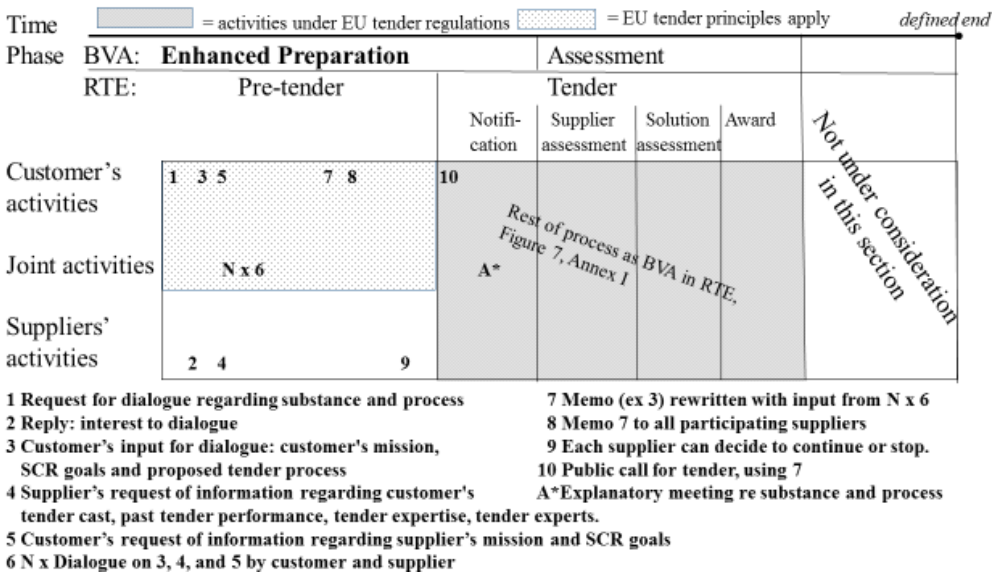


Figure 8: BVA activities in enhanced preparatory phase.

Market consultation can also be positioned as a dialogue, focusing on the tender process to be applied, next to the substance of the planned SCR. This constitutes an enhancement to the preparatory phase: enabling suppliers to air their experiences with and attitude towards participating in RTE tenders, suggest elements for such process, and show preference for certain RTE procedures. Without any obligation to use these ideas, the customer would benefit from adding these to its own expertise regarding choosing the procedure and setting the process. Suppliers can benefit from early contacts with the customer's team and tender details. The formal tender procedure will follow the steps as elucidated above. The tender of course being open to both suppliers participating in the preparatory dialogue and those who did not.

The preparatory phase would be utilized for interaction and relationship building mechanisms. This could be a forebode for bilateral process governance during the tender. This governance constellation is depicted in Figure 9.

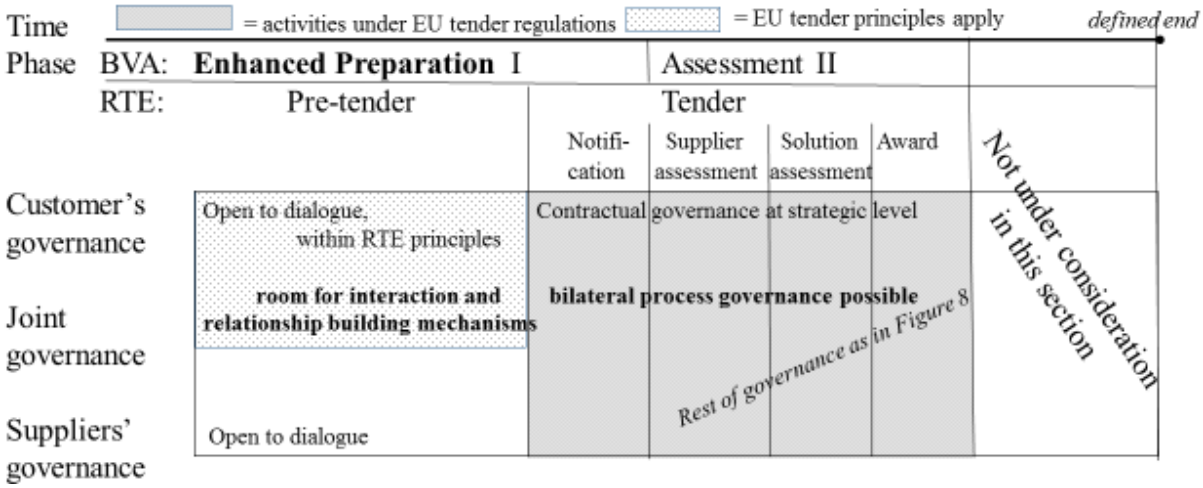


Figure 9: Governance with enhanced preparatory phase under BVA within RTE.

Conclusion & Discussion

It is concluded, such enhancement of the preparatory phase could improve the value of the SCR in two ways. First, bilateral governance is practiced right from the start, enabling early sense making mechanisms, promoting relational governance, and thus leading to a condition for maximizing the SCR performance and satisfaction. Second, by reducing the risk of negatively contrasting expectations: such misalignment foreshadows parties potentially destroying the SCR.

Within RTE, such enhancement can only take place in the – pre-tender part of the - Preparation phase. This added sense making during Preparation can improve the value of SCRs for both customers and suppliers in an early phase, to be built upon during the Assessment by applying bilateral process governance and continued sense making. Together, this will improve the employment of bilateral contractual and relational governance, prevention of misaligned expectations and early SCR dissolution, and solidify the performance to strategic goals during Execution. The Enhanced Best Value Approach therefor sets the conditions for maximizing SCR value and improving satisfaction for both parties.

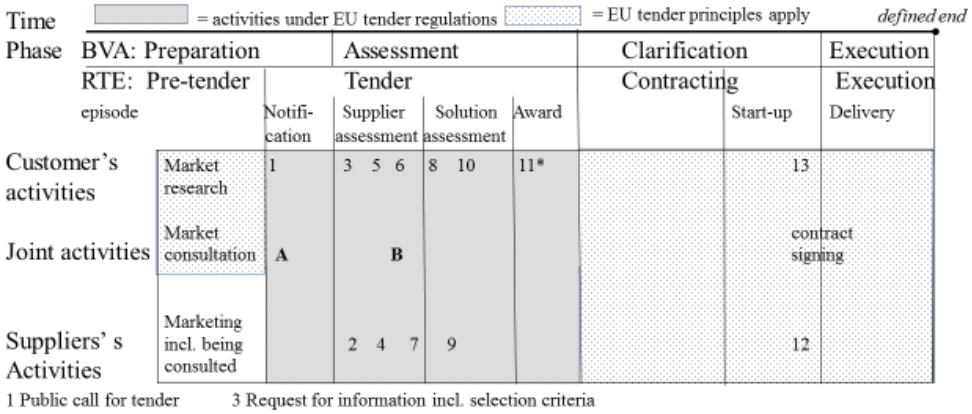
Suggestions for Future Action

For practitioners, the effect of this suggested enhancement can be tested in practice. Both customers and suppliers can take the initiative for this. Scholars could then study these effects. Regulators could contemplate the effects of their detailed regulations.

Appendix I

BVA activities in RTE phasing

To represent the BVA activities within RTE, the essentials of BVA (Figure 5) are now combined with the activities as normally performed within RTE (Figure 3). The phases, episodes, and BVA activities within RTE are presented in the figure below.



Appendix Figure 1: BVA activities within RTE. BVA specific activity or phasing in **bold.**

The figure has its own activity numbering, the BVA specifics are mentioned in bold. To show that activities in RTE are phased differently when using BVA or not, the phases and episode are both mentioned in the figure. The explanatory meeting (A) and the interview (B) are introduced in a RTE compliant way. The BVA variant of the qualification information (4) is the expertise shown by the suppliers through references and metrics. The offer submitted by each supplier in BVA (9) becomes the expert solution, including metrics, project capabilities, ranked risks and added values, named experts, priced to win and secure supplier's own aims. The notification of intended award becomes a notification pending clarification: only after the best offer has been sufficiently clarified, and a contract been agreed upon, all other suppliers which have send in their expert solution are on hold. The possibility to appeal and the final award (12 and 13) are therefore postponed.

References

Bergema, C. P. A. M. (2016). An Action Repertoire for the Collaboration in Innovation Networks.

Blau, P. (1964). Exchange and power in social life. *New York, Wiley 1964*.

Cao, Z., & Lumineau, F. (2015). Revisiting the interplay between contractual and relational governance: A qualitative and meta-analytic investigation. *Journal of Operations Management*.

Clauß, T. (2013). Strategische Zusammenarbeit mit Zulieferern: Empirische Befunde zur Governance im Kontext von Zielsetzung und Beziehung. *Betriebswirtschaftslehre Für Technologie Und Innovation Band-Nr. 67 Springer Fachmedien Wiesbaden 2013*.

Dwyer, F., Schurr, P., & Oh, S. (1987). Developing buyer-seller relationships. *The Journal of Marketing*.

Dyer, J. H., & Singh, H. (1998). The Relational View: Cooperative Strategy and Sources of Competitive Advantage. *The Academy of Management Review*, *23*(4), 660–679.

European Commission (2015*) TED Structured Dataset (2009-2014), Tenders Electronic Daily, supplement to the Official Journal of the European Union. DG Internal Market and Services;* received on 2015-03-18.

European Council (2014), *Directive 2014/25/EU of the European Parliament and of the council, on procurement by entities operating in the water, energy, transport and postal services sectors and repealing Directive 2004/17/EC*; WWW document; URL http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014L0025&from=EN

European Council (2014), *Directive 2014/24/EU of the European Parliament and the Council on public procurement and repealing Directive 2004/18/EC;* WWW document; http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014L0024&from=EN

Harmeling, C., & Palmatier, R. (2015). Relationship Dynamics: Understanding Continuous and Discontinuous Relationship Change. *Handbook of Research on Distribution Channels*.

Heide, J., & John, G. (1992). Do norms matter in marketing relationships? *The Journal of Marketing*.

Kashiwagi, D. (2015). *Best Value Approach*. *Group, Tempe, AZ. Publisher: KSM Inc*.

Kashiwagi, D., & Kashiwagi, J, (n.d.) Best Value Approach. Retrieved from https://ksmuniversity.ksm-inc.com/wp-content/uploads/2015/11/Class-Introduction.pdf

Kashiwagi, D., & Slater, C. (2003). Impact of Information Concepts on Construction Performance. In *Construction Research Congress* (pp. 1–11). Reston, VA: American Society of Civil Engineers.

Macneil, I. R. (1980). The new social contract: An inquiry into modern contractual relations.

Macneil, S. (1980). *The New Social Contract: An Inquiry into Modern Contractual Relations*. *Journal of Public Policy & Marketing* (Vol. 15).

Morgan, R., & Hunt, S. (1994). The commitment-trust theory of relationship marketing. *The Journal of Marketing*.

Poppo, L., & Zenger, T. (2002). Do formal contracts and relational governance function as substitutes or complements? *Strategic Management Journal*, *23*(8), 707–725.

Rijt, J., Witteveen, W., Santema, S. (2016). (2016). *Best Value stroomt, inzichten uit de praktijk, de jurisprudentie en de wetenschap*.

Rijt, J. van de , & Santema, S. C. (2012). The Best Value Approach in the Netherlands: A refection on past, present and future.

Rijt, van der J, & Santema, S. C. (2013). Prestatieinkoop: met Best Value naar succesvolle projecten.

Ring, P., & Ven, A. Van de. (1994). Developmental processes of cooperative interorganizational relationships. *Academy of Management Review*, *19*(1), 90–118.

Telgen, J., Harland, C., & Knight, L. (2006). Public procurement in perspective.
Tulling, D., Conflicts in Best Value, 2018, TUDelft repository.
Wang, S., & Bunn, M. (2004). Government/business relationships: insights into contract implementation. *Journal of Public Procurement*.
Williamson, O. E. (1985). The economic institutions of capitalism.
World Trade Organization. visited 2016; http://www.wto.org/english/tratop_e/gproc_e/gp_gpa_e.htm

Analysis of Cost Overruns in Saudi Arabia Construction Projects: A University Case Study

Majed Alzara (PhD)
Jouf University
Al-Jouf, Saudi Arabia

Jacob Kashiwagi (PhD), Dean Kashiwagi (PhD, PE)
Arizona State University
Tempe, AZ, United States

Abdulrahman Al-Tassan (PhD)
King Saud University
Riyadh, Saudi Arabia

Public projects in Saudi Arabia have been experiencing low construction project performance for the past decade. Studies have identified the low-bid delivery method as an important factor in causing such delays. In addition, low bids for contracts have not reflected the actual project cost. A case study was conducted at a university campus in northern Saudi Arabia in which the actual project costs for four projects were examined. The study found that all four projects' costs were higher than the original bid. In addition, a large survey was conducted of 804 classified contractors and universities representatives who identified change orders as the most common factor causing cost overruns in Saudi Arabia. Previous studies showed that some contractors aim to submit low bids for winning the competition then change orders to reduce their losses. Consequently, low bids also lead to cost overruns. In a comparison using the result of a case study and the results of the Performance Information Procurement System (PIPS), Saudi Arabia's delivery system was identified as a potential cause of project performance issues.

Keywords: cost, overruns, low-bid, Saudi Arabia, Best Value Performance Information Procurement System (BV PIPS).

Introduction

The Saudi construction industry has been developing since the establishment of Saudi Arabia, and the developments have only increased in recent years. From 1990 to 2000, investment funds in the Saudi construction industry totaled $234 billion (Cordesman, 2002). In 2013, US$48 billion was specified for construction projects via the Saudi Ministry of Finance. In addition, in 2014, it was found that more than $66 billion had been anticipated by the government for projects (Arab News, 2014). In 2015, the total cost of construction contracts was about $32 billion (Ministry of Finance, 2015). As shown above, the government of Saudi Arabia has pumped billions of dollars into the construction industry. However, it was found that 70% of public projects were delayed (Assaf & Al-Hejji, 2006). According to *Arab News* (2011), nonperformance in terms of construction projects put more than $147 billion at stake. In 1983, 70% of the public projects under the Ministry of Housing and Public Works were delayed (Zain Al-Abedien, 1983). One of the important factors for the delays, mentioned in previous studies, was the low-bid procurement system. Most Middle Eastern countries used the lowest bidding company, which is regarded as being the primary cause of construction delays in Saudi Arabia (Albogamy et al., 2013; Al-Khalil & Al-Ghafly, 1999; Mahamid, 2013; Alzara et al, 2016). In other words, contractors were selected based on price alone, ignoring contractor's performance side. In addition to the construction project delays, there were also cost overrun problems. This study investigates the selection of contractors using a low-bid method and cost overruns in a case

study focusing on a new university campus located in northern Saudi Arabia. The new university was established in 2005 and has been in the construction stage since 2006.

Problem

Compared to other countries, the procurement delivery system in Saudi Arabia is based primarily on low bidding prices. When contractors are selected, the only focus is price. These low-bid projects are affected by substandard performance and delays, which often leads to increased costs. The government of Saudi Arabia has spent billions of dollars on construction projects, and they select contractors according to the lowest bid. However, these projects are often affected by cost overruns. This shows a contradiction in the way that contractors are selected because the system relies on cost criteria, but this leads to additional spending during the execution phase. The case study of a new university campus shows substandard performance during construction, which should have been completed in 2012. The delays range from 50 to 150% among different campus buildings (Alzara et al., 2016). The procurement delivery system in Saudi Arabia should be reconsidered to increase project performance and save money.

Research Hypothesis

The criterion of selecting contractors based on the lowest bid does not reflect the true price of projects. Also, the current project management methodology of the new university's owner uses has led to cost overruns.

Objective

The objective of this study is to persuade stakeholders in Saudi Arabia that selecting contractors based on price criterion alone costs the government more due to substandard construction performance and cost overruns.

Methodology

In this study was discovered a relationship between low-price bidders and cost overruns through a literature review. The case study was conducted at the new university in northern Saudi Arabia, which uses the low-bid system. Data were collected that included only projects that have complete information available about bidders and cost overruns. Four construction projects were selected for which the complete data could be analyzed to examine cost overruns and show that the actual costs were higher than the original proposed prices. After this, a project director and five engineers at the university were interviewed. They outlined their method for selecting contractors and identified the causes of the cost overruns. Once these causes had been found, 804 classified contractors and representatives of universities were surveyed regarding the general causes of cost overruns. A statistical analysis of the survey data was conducted. Next, the study explained how the Performance Information Procurement System (PIPS) works and discussed some case studies that used PIPS, which approved a high level of performance with no cost

deviation. In comparing these PIPS case studies with case studies from new university, the criteria of the low-bid procurement delivery system used in Saudi Arabia conflict with the desired results.

Literature Review

Construction projects in Saudi Arabia have long-faced issues regarding low performance. Of public construction projects in Saudi Arabia, 70% have experienced delays (Al-Sultan, 1987; Assaf & Al-Hejji, 2006; Zain Al-Abedien, 1983). Previous studies found that the major cause of delays in construction projects in Saudi Arabia is the use of a bid delivery system based on low prices (Albogamy et al., 2013; Al-Khalil & Al-Ghafly, 1999; Assaf & Al-Hejji, 2006; Mahamid, 2013). The most significant factor is the selection of contractors according to the lowest bid in terms of construction (Banaitiene & Banaitis, 2006; Hatush & Skitmore, 1997a; Holt, Olomolaiye, & Harris, 1995; Huang, 2011; Merna & Smith, 1990; Moore, 1985; Ng & Skitmore, 2001; Plebankiewicz, 2008, 2010; Singh & Tiong, 2006; Waara & Brochner, 2006). Project time and quality are unimportant in comparison (Herbsman & Ellis, 1992). Hence, project performance is affected when contractors are chosen based on the lowest price while disregarding quality and time (Holt, Olomolaiye, & Harris, 1994).

A study conducted in the United Kingdom, that encouraged the conversion from selecting contractors according to a low-bid delivery system to a performance-based norm, showed that the price of bids was not significant (Wong, Holt, & Cooper, 2000). In addition, it was found that the selection of eligible contractors from other bidders, regardless of the lowest bid, could have a positive impact on project cost and performance (Iyer & Jha, 2005). However, when the delivery system was based on only price, it encouraged unqualified contractors to submit bids (Herbsman & Ellis, 1992). Therefore, construction projects were affected by cost overruns and project delays due to the rewarding of projects to unqualified contractors (Koushki, Al-Rashid, & Kartam, 2005).

According to Banaitiene and Banaitis (2006), the selection of unqualified contractors causes price changes and increases the cost of projects. However, the appropriate awarding of construction projects to qualified contractors can increase project success (Alhazmi & McCaffer, 2000). This has also been confirmed by other studies (Plebankiewicz, 2009). The selection of contractors is, however, considered to be complex (Sari & El-Sayegh, 2007), and project holders face difficulties when they make the decision to select appropriate contractors (Hatush & Skitmore, 1997b). Likewise, it was found that contractor selection in Saudi Arabia is a challenge for project owners due to the fact that it will subsequently affect project accomplishment and the level of satisfaction (Price & Al-Otaibi, 2010).

Experts in the construction industry have found that the method of contractor selection in Saudi Arabia often fails to meet owner expectations, which has been proven through the many problems reported, such as contractor failure, cost overruns, increasing changes, poor quality, and claims (Abu Nemeh, 2012). Another study showed that, in the public sector, the selection of qualified contractors is further affected by obstacles such as a lack of capable consultants, difficulty making decisions due to a lack of experience, and organizational stress regarding

achieving the targeted budget within the allotted timeframe (Al-Busaad, 1997). According to Al-Hazmi (1987), cost overruns, order modifications, substandard quality, and contractor insolvency are caused when contractors win the bid by submitting the lowest price (Al-Hazmi, 1987). In addition, it was found that bidders aim to win by providing the lowest cost when the bid is based on price (Cheng, 2008). Hence, there exists the possibility that the actual cost of projects is not being represented if a cost-based contractor selection method is applied (Olaniran, 2015). One study showed that a bidder who has the lowest bid frequently provides an estimate that is lower than the appraised cost of the project (Capen, Clapp, & Campbell, 1971). Contractors, who select bids based on the lowest price, face profit risk and loss risk (Chao & Liou, 2007). Moreover, the bidder with lowest price should commit to the implementation of a project despite other bidders do not accept the project at that price (Wolfsetter, 1996). In a low-bid procurement delivery system, bidders have used many techniques to win bidding competitions. It was discovered that some bidders inspect bidding documents to discover mistakes that will assist them in change orders and claims if they have projects in the future (Doyle & DeStephanis, 1990).

Predatory bidding is a term that refers to bidders who use low bids to win projects and subsequently make changes to project instructions and claims to reduce their losses (Crowley & Hancher, 1995). Therefore, the actual costs are not reflected in abnormally low bids due to the many changes in orders and claims that bidders will focus on (Bedford, 2009). This is one method that contractors use to offset their losses when they win contracts through low bids (Zack, 1993). Olaniran (2015) conducted an online questionnaire and surveyed 54 construction practitioners. One of his research goals focused on identifying reasons for project performance problems caused by cost-based contractor selection. His study uncovered 22 reasons; the highest-ranked reason, with a significance index of 78.93, was that contractors reduced their profit margins. The next reason, with a significance index of 59.39, was the poor level of project monitoring and control engaged in by many contractors. The third reason was contractor incompetence, with a significance index of 57.16 (Olaniran, 2015). However, project quality can be affected over the long term when contractors reduce profit margins, which can lead to substandard performance (Han, Park, Kim, Kim, & Kang, 2007).

Rather than using the low-bid system, another procurement system, best value procurement (BVP), can be used to improve project performance. BVP has proven performance in leading to quality construction projects. In this strategy, contractors are selected based on high performance and lowest price. Then contractors move to the important clarification phase, in which all the details of a proposal are explained, including delivery information through a specific technique (Kashiwagi & Kashiwagi, 2011). The clarification phase will be explained in the best value case studies section. In addition, a previous study identified major delay risk factors for poor performance in Saudi Arabia and identified BV PIPS as a solution for overcoming delay risk factors (Alzara et al., 2016).

A New University Case Study

The new university campus selected for this case study is in northern Saudi Arabia. This campus consists of 21 colleges in addition to other facilities and serves approximately 26,000 students. The university campus required several construction stages to be completed. It was found that, of

22 construction projects, 17 were delayed. The new university campus should have been completed in 2012; however, only two buildings were operational as of 2015. In April 2015, data were collected from the new university to identify cost overruns when the criteria for selecting contractors were based on price alone. The delivery system at the university is based on the low-bid method. This study concentrated on obtaining complete data regarding projects from the beginning of the project to the current period. It was found that only four projects contained complete project information. That difficulty in collecting data existed because the university's construction projects had transitioned through many stages and various responsible authorities since their execution in 2006. The four case studies showed all bidder costs for each project and which contractors had been selected. Moreover, the data contained the actual costs obtained during the execution phase. All personal information regarding the contractors, including their names, was coded for this study.

In case study one, there were five bidders. The lowest bid came from Cont AAAFS at $31,605,544, and the highest was provided by Cont AAMASC at $59,333,506. The budget of project one was $34,538,933. In this example, the lowest bid won the project. When the final data were collected, the actual project only reached 24% completion and the actual price was $38,666,667, as shown in Table 1.

Table 1: Data Regarding Case Study One.

Project 1					
Bidders	**Cost**	**Result**	**Budget of project**	**Actual value at 24% completion**	**Percent of cost deviation**
Cont AAAFS	$31,605,544	Selected	$ 34,538,933	$38,666,667	22.3%
Cont ATCCSA	$42,185,088				
Cont FTCC	$44,368,791				
Cont WIAC	$47,940,058				
Cont AAMASC	$59,333,506				

In case study two, five bidders applied. The lowest bid, provided by Cont AMG, was $24,645,130, whereas the highest bid, provided by Cont AAU, was $40,678,645. However, the lowest and second-lowest bidders left the competition with bids of $40,678,645 and $35,422,798, respectively. Then, from the three remaining contractors, the project owner selected the lowest bid, which was provided by Cont SACC at $37,317,248. However, the budget for project two was $35,733,333. After negotiations between the project owner and contractor, they signed the contract with a price of $34,666,667. The actual value, at 60% project completion, was $43,466,667. Table 2 shows the details for case study two.

Table 2: Data Regarding Case Study 2.

Project 2					
Bidders	**Cost**	**Result**	**Budget of project**	**Actual value at 60% completion**	**Percent of cost deviation**
Cont AMG	$24,645,130	Withdrawn	$ 35,733,333	$ 43,466,667	25.4%
Cont ATCCSA	$35,422,798	Withdrawn			
Cont SACC	$37,317,248	Selected			
Cont BCL	$39,474,272				
Cont AAU	$40,678,645				

Five vendors bid on case study three. The lowest bid, provided by Cont DMC, was $38,501,294, whereas the highest bid, provided by Cont ACCL, was $45,530,146. The budget for project three was $40,000,000. The project owner selected the contractor with the lowest price, which was Cont DMC at $38,501,294. However, the actual value, at 80% completion, was $41,866,667. The bidding information is shown in Table 3.

Table 3: Data Regarding Case Study 3.

Project 3					
Bidders	**Cost**	**Result**	**Budget of project**	**Actual value at 80% completion**	**Percent of cost deviation**
Cont DMC	$38,501,294	Selected	$ 40,000,000	$ 41,866,667	8.7%
Cont AAF	$40,397,923				
Cont BCL	$40,883,645				
Cont ACC	$41,919,152				
Cont ACCL	$45,530,146				

The fourth case study focused on project four in which five contractors applied for the project. The lowest price, provided by Cont AMG, was $27,070,573, whereas the highest price, provided by Cont BCL, was $40,965,773. The budget for the project was $28,000,000. Therefore, Cont AMG won the competition with the lowest price, $27,070,573. However, the actual value of the project at 62% completion totaled $39,200,000. The bidding information is shown in Table 4.

Table 4: Data Regarding Case Study 4.

Project 4					
Bidders	**Cost**	**Result**	**Budget of project**	**Actual value at 62% completion**	**Percent of cost deviation**
Cont AMG	$ 27,070,573	Selected	$ 28,000,000	$ 39,200,000	44.8%
Cont ATCCSA	$ 33,554,292				
Cont SACC	$ 36,304,503				
Cont AAU	$ 40,434,665				
Cont BCL	$ 40,965,773				

A New University Case Study Analysis

All the four new university case studies analyzed experienced cost overruns. As mentioned above, all these projects used the low-bid delivery system. In case study one, a contractor, AAAFS, was selected based on its low bid; however, cost overruns of 24% at completion totaled approximately $7,061,123. In case study two, there was approximately $6,149,419 in cost overruns in comparison to the bid price, and $8,800,000 in cost overruns at 60% completion in comparison to the signed contract. In case study three, a contractor, DMC, was selected due to the low bid price; however, this project experienced $3,365,373 in cost overruns. Moreover, the completion rate for that project was 80%. In case study four, a contractor, AMG, was selected due to its low bid price, and cost overruns reached $12,129,427. The percentage of completion in case study four was 62%. Figures 3, 4, 5, and 6 show the selected contractors in comparison to other bidders and cost overruns. The total of cost overruns for these case studies is $31,355,923. This wasted amount is equivalent to the cost of one university building. The low-bid system has been proven to offer substandard performance and cost overruns at the new university campus. Table 5 shows the details regarding cost overruns for the case studies. Although the instruction

of the procurement system does not allow of cost overruns to exceeding 10% of the total value of the contract, however, dividing bids into several parts breaks this rule.

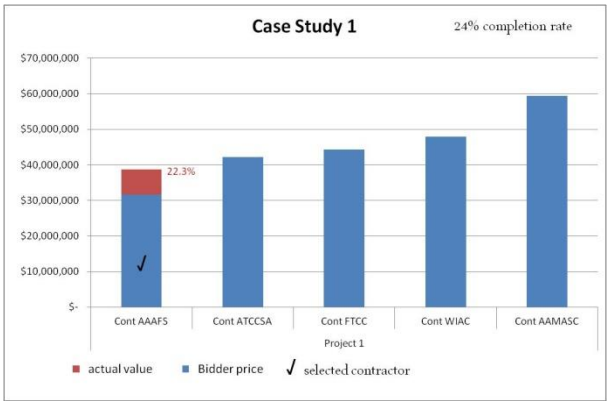


Figure 3. Selected contractor and cost overruns in case study one.

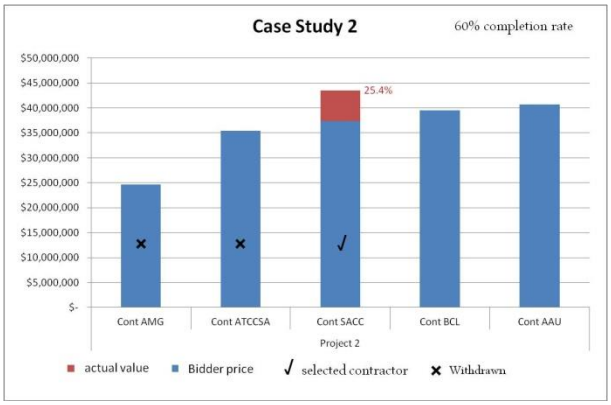


Figure 4. Selected contractor and cost overruns in case study two.

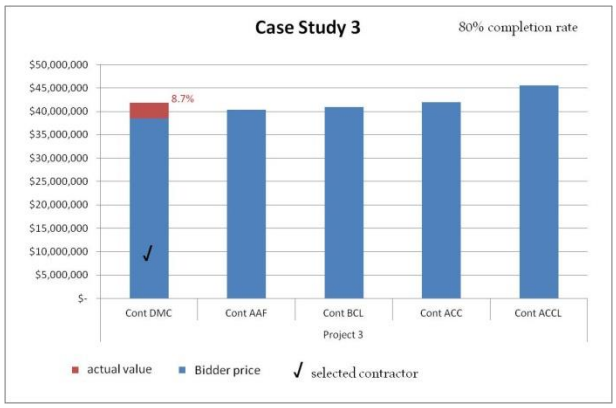


Figure 5. Selected contractor and cost overruns in case study three.

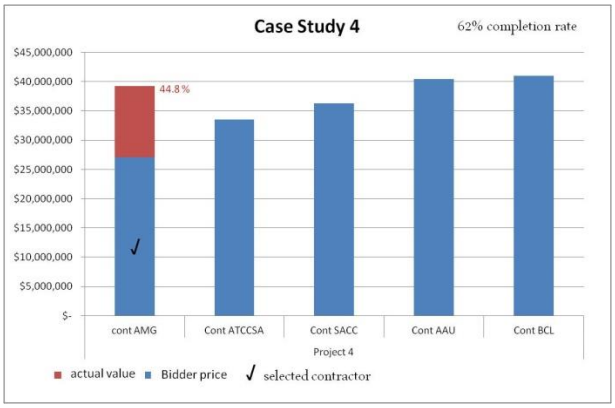


Figure 6. Selected contractor and cost overruns in case study four.

Table 5: Details of Case Study Cost Overruns.

	Case study 1	Case study 2	Case study 3	Case study 4	Average
Contract Value	$31.6 Million	$34.6 Million	$38.5 Million	$ 27 Million	$ 32.9 Million
Total Cost of Contracts	131.7 Million				
Percent overrun	22.3%	25.4%	8.7%	44.8%	23.3%
Cost overrun	$ 7.1 Million	$8.8 Million	$3.4 Million	$12.1 Million	$7.8 Million
Total	$31.4 Million				

Survey

A project director and five engineers at the new university were interviewed, and they identified seven risk factors that could cause cost overruns in Saudi Arabia. These seven risk factors were change orders, bid proposal errors, contractor's errors, consultant's errors, client's change of scope, dividing bids into several parts, and unforeseen risks. The survey consisted of three parts: Daley causes, cost overruns causes, and the procurement system. The first and third parts used in

other searches. The second part that used in this study was sent to more than 1,500 classified contractors and 14 project departments of universities in Saudi Arabia for rating the seven risk factors that caused cost overruns (see Appendix). The survey was responded to by 761 classified contractors and 43 representatives of universities. Table 6 shows the result of the survey.

Table 6: Survey Result.

Causes of cost overruns	Representatives of universities			Classified contractors		
	Not Common	Don't Know	Common	Not Common	Don't Know	Common
Client's Change of Scope	4.65%	18.60%	76.75%	6.57%	15.90%	77.53%
Unforeseen Risks	18.61%	30.23%	51.16%	14.72%	34.82%	50.46%
Change Orders	0.00%	4.65%	95.35%	5.52%	12.88%	81.60%
Bid Proposal Errors	13.95%	9.30%	76.75%	8.28%	12.88%	78.84%
Contractor's Errors	13.95%	34.89%	51.16%	24.84%	38.50%	36.66%
Consultant's Errors	27.91%	41.86%	30.23%	10.12%	41.79%	48.09%
Dividing Bids into Several Parts	18.61%	30.23%	51.16%	14.72%	35.74%	49.54%

Survey Statistical Analysis

Validity

The construct validity was used to assess the validity of the items of the cost overrun causes the project in new Saudi Arabian universities. The Pearson's correlation was used to evaluate the relationship between each item and the total representing all the items. Generally, a correlation value of 0.70 or higher reflects a strong (high) relationship, and the item is consistent with the total of the items. The results are included in table (7). The formula for calculating r is:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[\, n\Sigma x^2 - (\Sigma x)^2 \,][\, n\Sigma y^2 - (\Sigma y)^2 \,]}}$$

Where: (n) is the sample size
(x) is the item values
(y) is the total of the items

The correlation values shown in table 7 reflect a very strong relationship between each item of the cost overrun and the total of the items, suggesting very satisfactory construct validity. All the values were statistically significant at 0.05 and 0.01 levels. Note that most of the values provided in the table were close to the integer 1, which represents the maximum possible value a relationship may reach. The minimum correlation (but considered to express high correlation) value was observed between item no. 1 (Change Orders) and the cost overrun (0.841). A value of 0.70 or higher is considered to express a strong relationship.

Table 7: The Construct Validity for the Cost Overrun Causes (all sample n=804).

Item no.	Cost overrun causes	Over all causes
1	Change Orders	0.841
2	Bid Proposal Errors	0.888
3	Contractor's Errors	0.884
4	Consultant's Errors	0.911
5	Client's Change of Scope	0.890
6	Dividing Bids into Several Parts	0.949
7	Unforeseen Risks	0.948

Reliability

The approach of internal consistency for Cronbach's alpha was used to describe how much the items of the cost overrun are reliable to measure these causes. This approach is based on calculating the ratio of the sum of item variance to the variance representing the total items and adjusting the answer to the number of items. The formula for calculating α is:

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum_i V_i}{V_t}\right)$$ (Cronbach, 1951, p. 299)

Where: n is the number of items
V_i is the item variance
V_t is the variance of the items total

The value of the internal consistency provided in table 8 suggests strong reliability. A value of 0.60 or greater expresses good reliability, so the provided values express a high degree of consistency (here also the maximum possible value that may be obtained is 1).

Table 8: Reliability Analysis Using Cronbach's Alpha
the cost overrun causes (overall sample n=804).

	No. of items	**Value**
Cost overrun causes	7	0.960

Prioritizing causes of cost overruns

The following formulas were used to calculate the included statistical indices:

1. The mean
   Mean (m) = Σ [a. (n/N)]
   Where:
   (a) is the weight being used
   (n) The weight frequency
   (N) is the sample size

2. The standard deviation

$$SD = \sqrt{\frac{\sum (x - \bar{x})^2}{N-1}}$$

   Where:
   (x) is the response value
   (x bar) is the mean
   (n) is the sample size

3. Frequency index (F.I.) is the percentage of the mean being assessed out of the highest response weight
   F.I = Σ [a. (n/N)] × 100/10 Where:
   (a) is a constant of weighting given to each respond (1=not common, 5=don't know, 10=common),
   (n) is the frequency of weight
   (N) is the total number of responses for this research

Table 9 reflects the descriptive statistics for the cost overrun causes for new Saudi Arabian university projects from the contractor's perspective. The results show that item no. 1 (Change Orders) is ranked first as it recorded the greatest FI (88.6), while item no. 3 (Contractor's Errors) is ranked last as it recorded the lowest FI (58.6). All other values ranged between these two values. It is noted that the top three cost overrun causes had a score above 80.0 FI.

Table 9: Descriptive statistics for the causes of cost overruns according to contractors arranged in descending order (contractor's sample n=761).

Cause code	Item	Frequency %			mean	SD	FI*	order
		Not common (1)	Don't know (5)	Common (10)				
1	Change Orders	5.5	12.9	81.6	8.86	2.53	88.6	1
2	Bid Proposal Errors	8.3	12.9	78.8	8.61	2.83	86.1	2
5	Client's Change of Scope	6.6	15.9	77.5	8.61	2.72	86.1	2
4	Consultant's Errors	10.1	41.8	48.1	7.00	3.11	70.0	4
7	Unforeseen Risks	14.7	34.8	50.5	6.93	3.35	69.3	5
6	Dividing Bids into Several Parts	14.7	35.7	49.5	6.89	3.34	68.9	6
3	Contractor's Errors	24.4	38.9	36.7	5.86	3.52	58.6	7

(*) mean percentage out of the maximum weight (10)

Table 10 reflects the descriptive statistics for the cost overrun causes for new Saudi Arabian university projects from the perspective of university representatives. The results show that item no. 1 (Change Orders) is ranked first as it recorded the greatest FI (97.7), while item no. 4 (Consultant's Errors) is ranked last as it recorded the lowest FI (54.0). All other values ranged between these two values. It is noted that the top three cost overrun causes had a score above 80.0 FI.

Table 10: Descriptive statistics for the causes of cost overruns according to representatives of universities arranged in descending order (university representatives n=43).

Cause code	Item	Frequency %			mean	SD	FI*	order
		Not common (1)	Don't know (5)	Common (10)				
1	Change Orders	0.0	4.7	95.3	9.77	1.07	97.7	1
5	Client's Change of Scope	4.7	18.6	76.7	8.65	2.60	86.5	2
2	Bid Proposal Errors	14.0	9.3	76.7	8.28	3.30	82.8	3
3	Contractor's Errors	14.0	34.9	51.2	7.00	3.36	70.0	4
6	Dividing Bids into Several Parts	18.6	30.2	51.2	6.81	3.57	68.1	5
7	Unforeseen Risks	18.6	30.2	51.2	6.81	3.57	68.1	6
4	Consultant's Errors	27.9	41.9	30.2	5.40	3.49	54.0	7

(*) mean percentage out of the maximum weight (10)

Table 11 reflects the descriptive statistics for the cost overrun causes for new Saudi Arabian university projects from both the perspectives of the contractors and university representatives. The results show that item no. 1 (Change Orders) is ranked first as it recorded the greatest FI (89.1) while item no. 3 (Contractor's Errors) is ranked last as it recorded the lowest FI (59.2). All other values ranged between these two values.

Table 11: Descriptive statistics for the causes of cost overruns according to contractors and representatives of universities arranged in descending order (contractors and university representatives n=804)

Cause Code	Item	Frequency %			Mean	SD	FI*	Order
		Not common (1)	Don't know (5)	Common (10)				
1	Change Orders	5.2	12.4	82.3	8.91	2.48	89.1	1
5	Client's Change of Scope	6.5	16.0	77.5	8.62	2.71	86.2	2
2	Bid Proposal Errors	8.6	12.7	78.7	8.59	2.86	85.9	3
7	Unforeseen Risks	14.9	34.6	50.5	6.93	3.36	69.3	4
4	Consultant's Errors	11.1	41.8	47.1	6.91	3.15	69.1	5
6	Dividing Bids into Several Parts	14.9	35.4	49.6	6.88	3.36	68.8	6
3	Contractor's Errors	23.9	38.7	37.4	5.92	3.52	59.2	7

(*) mean percentage out of the maximum weight (10)

Best Value Case Studies

In 1991, the Best Value Approach (BVA) was instituted by Dr. Kashiwagi at Arizona State University (ASU). The BVA has proven that the utilization of experts can both increase project performance and minimize risks. Logic and common sense are the principles of BVA, through which decision-making, management, and control can be minimized. Project performance is affected when projects apply value to, or are based on, price. The industry structure model shows that projects obtain high levels of performance when value based, and experienced substandard performance when piece based, as shown in Figure 1. The Best Value Procurement/Performance Information Procurement System (BVP/PIPS), developed by Dr. Kashiwagi's team at ASU, is the Performance Based Studies Research Group (PBSRG). PIPS work by finding expert contractors and increasing project performance. Construction projects completed according to PIPS were completed on time, with a high level of quality, and completed on budget. PIPS was checked over 1,750 times in projects that amounted to $6.3 billion, with $4 billion of these projects in the construction sector. These projects had a 98% rate of success in six diverse countries and 31 states (Kashiwagi, 2014).

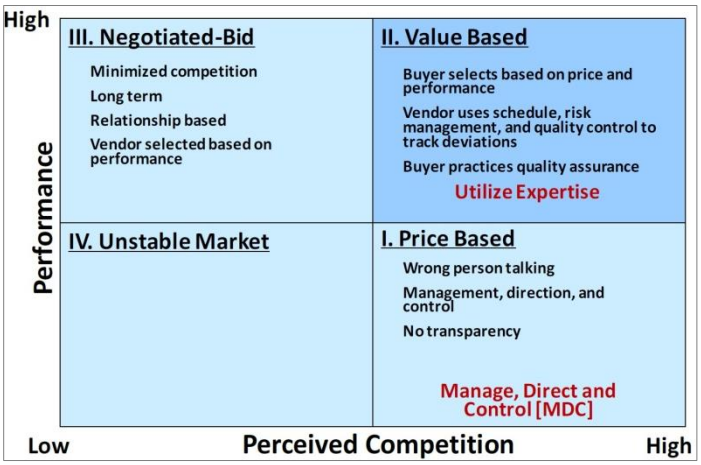


Figure 1. Industry structure model (Kashiwagi, 2014).

The PIPS process involves four phases: pre-qualification (optional), selection, clarification, and execution. In the clarification phase, vendors are educated regarding BVA and submit dominant metrics to prove vendor performance. The second phase, selection, has four filters to find an appropriate vendor for a project. The selection filters are project capability, interview, prioritize (identify best value), and dominance check for an appropriate vendor (see Figure 2). The third phase is clarification, which is the most significant phase. A vendor should provide a plan for a project from the beginning to the end, including detailed technical specifications, a milestone schedule, the project scope, and a risk management plan. In the execution phase, the final phase of PIPS, a vendor must deliver a Weekly Risk Report (WRR) and a Director's Report (DR) to an owner. WRR and DR are Excel documents that show a milestone schedule, risk management plan, and performance measurements.

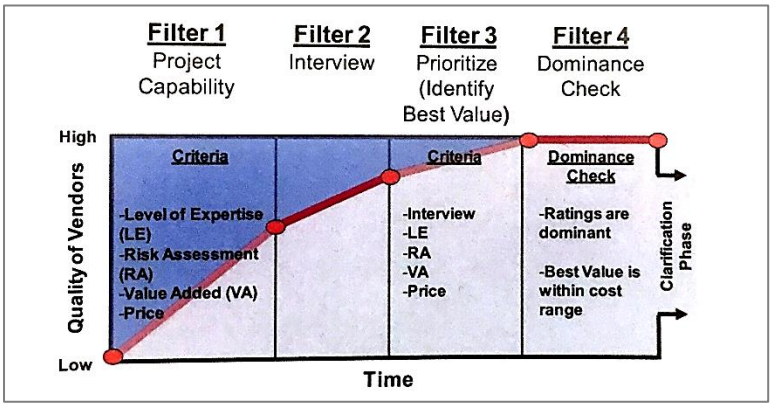


Figure 2. Shown selection phase filters (Kashiwagi, 2014).

The PIPS process has proven successful when applied. Table 12 shows case studies that have applied PIPS. These case studies show that 100% of the projects that utilized PIPS finished within their budget. Moreover, most of these projects also finished on time. There were no changes to orders, and these projects received a high percentage of overall satisfaction from the project owners. PIPS consider both cost and performance when selecting a contractor rather than price only (CFMA's, 2006; Chan, 2004; Egan, 1998; PBSRG, 2010; Kashiwagi, 2010, 2011).

Table 12: Examples of PIPS Case Studies.

Case studies / Criteria	United Airlines	Utah	The University of Hawaii	Minnesota
Duration of execution	1996–1998	1999–2011	2000–2005	2005–present
Number of projects	32	4	11	247
Cost	$ 13 Million	$ 64,405,100	$ 1,658,192	$97.2 Million
Overall satisfaction	100%	N/A	92%	95%
On time	98%	100%	100%	100%
On budget	100%	100%	100%	100%
Change orders	0%	0%	N/A	0%

(adapted from Kashiwagi, 2014).

BVA and PIPS showed a high level of construction performance in PIPS case studies. Of the cases studied, 100% stayed within budget, and there were no changes in orders. BVA and PIPS used many phases and filters to find expert contractors with high levels of performance. In addition, projects in which PIPS was applied recorded extremely high percentages of on-time delivery and high satisfaction levels. When contractors were chosen, the clarification phase identified everything within the contractor's scope and plan from the beginning to the end. Moreover, during the execution phase, PIPS provided many tools to increase project performance through applied risk management and performance measurement. In contrast, the low-bid method depended on price alone when awarding projects. Then, during the execution stage, projects exhibited low performance, delay issues, and cost overruns. As mentioned in the literature review, contractors who won projects according to the low-bid method provided very low prices to win contracts only to later change project orders to increase profit. These situations lead to cost overruns.

The low-bid strategy considers the price criterion alone; however, the selection phase of PIPS considers both performance and price. Consequently, PIPS locates expert contractors with high performance and low prices. Also, it prevents cost overruns through four phases. According to Kashiwagi (2011), the most important phase is clarification. During this phase, a selected contractor should make a risk management plan (RMP) that includes all risks related to the contractor and owner. Also, the contractor should provide a milestone schedule. Moreover, the parties should negotiate technical requirements and the method of delivery. In the execution phase, the contractor should submit WRR and DR. Consequently, projects utilizing PIPS have demonstrated 100% delivery of projects within budget and on time.

Conclusion

The low-bid method and its results lead to significant costs for the Saudi Arabian government because the lowest bids do not reflect the actual price of projects. This study analyzed four previous case studies that were built on a university campus, each of which contained complete project information. In case study one, the cost overruns totaled approximately $7,061,123, with 22.3% cost deviation. In case study two, the cost overruns were approximately $8,800,000, with 25.4% cost deviation. Case study three experienced approximately $3,365,373 in cost overruns, with 8.7% cost deviation. In case study four, the cost overruns reached approximately $12,129,427, with 44.8% cost deviation. The total cost overruns for these case studies totaled approximately $31,355,923. This occurred in just four projects, showing what occurs when contracts are awarded to contractors based on price alone. Paradoxically, when the government wishes to save money by awarding projects to the lowest bidders, these projects end up costing a significant and unexpected amount of money and experience numerous delays.

Interviews with a project director and five engineers at the university case study identified seven risk factors that could cause cost overruns in Saudi Arabia. After the survey was conducted, the 761 classified contractors and 43 universities' representatives rated seven risk factors. The overall result showed that "change orders" was ranked first with a recorded FI of (89.1). The

classified contractors rated this factor with a FI of (88.6) and the universities' representatives rated this with a FI of (97.7). "Client's change of scope" was ranked second with a recorded FI of (86.2). The classified contractors rated this with a FI of (86.1) and universities' representatives gave it a FI of (86.5). The third factor was "bid proposal errors," which comprised an overall FI of (85.9). The classified contractors rated this with a FI of (86.1) and the universities' representatives with a FI of (82.8). "Unforeseen risks" was ranked fourth among risk factors. Overall, it received a FI of (69.3). The classified contractors rated this with a FI of (69.3), and universities' representatives ranked it with a FI of (68.1). "Consultant's errors" was ranked fifth; overall it received a FI of (69.1). The classified contractors rated this with a FI of (70.0), and universities' representatives rated it with a FI of (54.4). The cause of cost overruns that the sample group ranked sixth was the issue of "dividing bids into several parts," which received an overall FI of (68.8). The classified contractors rated this with a FI of (68.9) and universities' representatives rated it with a FI of (68.1). The last factor is "contractors' errors," which received a FI reading of (59.2). The classified contractors rated this with a FI of (58.6) and universities' representatives rated it with a FI of (70.0).

Thus, "changed orders," "client's change of scope," and "bid proposal errors" are the most significant causes of cost overruns in Saudi Arabia. Conversely, BVA and PIPS display a high level of construction performance—100% of such projects stay within budget and are completed on time with 0% changed orders. PIPS has demonstrated the ability to locate expert contractors with the highest performance levels and the lowest price. During the clarification phase, expert contractors will clarify and consider all risks that could happen during the execution phase and cause cost deviation. Therefore, PIPS can save project budgets from waste by using multiple phases and filters to award projects to expert contractors. This study recommends an adjustment of the current procurement model so that in the future, Saudi Arabia runs projects using the BV and PIPS systems instead.

Appendix

Survey

Part 1 Instructions: Please rate project delay causes in Saudi Arabian universities, with 1 meaning "not common," 5 meaning "don't know," and 10 meaning "common." Please only use one of these three choices for each question.

Criteria	**Rating (1, 5, or 10)**
Bidding System (Low Price)	
Poor Contractor Performance	
Lack of Experienced Contractors	
Manpower Shortage	
Inadequate Contractor Qualifications	
Material Delivery	
Owner's Late Design Document Review and Approval	
Delay in Progress Payments to Contractors	
Lack of Consultancy Employees	
Lack of Vision	
Design Requirements Do Not Reflect Reality	
Owner Controlled Designer	
Lack of Project Budget	
Owner's Wrong Decision Making	
Owner Did Not Follow Solidarity Conditions	
Inadequate Project Management Department	
Changing Consultant During Implementation	
Conflict among Company Partners	
Contractor Did Not Study Proposal	
Contactor Lacked Project Management Skills	
Contractor Ability	
Concurrent Projects	
Delayed Payment to Laborers	
Poor Consultant Performance	
Consultant Delayed Project to Extend His or Her Contract with Owner	
Unclear Procurement System	
New Worker Regulations	

Part 2 Instructions: please rate the causes of cost overruns to projects in Saudi Arabian universities, with 1 meaning "not common," 5 meaning "don't know," and 10 meaning "common." Please only use one of these three choices for each question.

Criteria	**Rating (1-5 or 10)**
Client's Change of Scope	
Unforeseen risks	
Change Orders	
Bid Proposal Errors	
Contractor's Errors	
Consultant's Errors	
Dividing Bids into Several Parts	

Part 3 Instructions: please fill in the survey below by providing a rating per question. 1 means you "disagree," 5 means you "don't know," and 10 means you "agree." Please only use one of these three choices for each question.

No.	Questions	Rating (1-5 or 10)
Current Procurement System		
1	I have high satisfaction with the current procurement system	
2	Do you think selecting contractors solely based on price is the optimal practice for procuring services?	
Best Value Principles		
1	Do you think selecting contractors based on performance with price would be better?	
2	Would you support improvements to the current procurement system that selects contractors based on performance with price?	
3	I would you be interested in learning more about a new procurement model that may improve the current procurement system by identifying and utilizing expertise.	
New Proposed Procurement System Improvements		
1	In addition to evaluating price, would requiring contractors to submit verifiable performance information improve the procurement process?	
2	In addition to evaluating price, would requiring contractors to submit potential risks they foresee on the project and how they will mitigate and manage them improve the procurement process?	
3	In addition to evaluating price, would requiring contractors to propose ways they can add value to a project in their proposal improve the procurement process?	
4	During the clarification period, would interviewing the selected contractor's project manager performing the work improve the procurement process?	
5	During the clarification period, would requiring the selected contractor to provide a project plan from beginning to end, including scope of work, technical and milestone schedule, major risks that fall outside of that scope before they receive a contract, and how they will measure their performance, improve the procurement process?	
6	During the execution of a project, would project performance increase if contractors measured their performance (time, cost, quality) weekly and submitted to clients?	
7	Would it be beneficial if the government documented all performance on projects and posted the performance for all contractors to compare?	
8	Would these new procurement processes improvements help to identify expertise and use it to improve overall performance on projects?	

References

Abu Nemeh, M. H. A. (2012). *Multi-criteria decision making model for the selection of a construction contractor in Saudi Arabia* (Master's thesis). King Fahd University of Petroleum and Minerals, Saudi Arabia.

Albogamy, A., Scott, D., Dawood, N. (2013). Dilemma of Saudi Arabian construction industry. *KICEM Journal of Construction Engineering and Project Management, 3*(4), 35–40.

Al-Busaad, S. A. K. (1997). *Assessment of application of life cycle cost on construction projects* (Doctoral dissertation). King Fahd University of Petroleum and Minerals, Saudi Arabia.

Al-Hazmi, M. (1987). *Causes of delay in large building construction projects* (Master's thesis). King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia.

Alhazmi, T., & McCaffer, R. (2000). Project procurement system selection model. *Journal of Construction Engineering and Management, 126*(3), 176–184.

Al-Khalil, M. I., & Al-Ghafly, M .A. (1999). Delay in public utility projects in Saudi Arabia. *International Journal of Project Management, 17*(2), 101–106.

Al-Sultan, A. S. (1987). *Determination of construction contract duration for public projects in Saudi Arabia* (Master's thesis). KFUPM, Dhahran, Saudi Arabia.

Alzara, M., Kashiwagi, J., Kashiwagi, D., & Al-Tassan, A. (2016). Important Causes of Delayed Projects in Saudi Arabia vs. PIPS: A University Campus Case Study. *Journal for the Advancement of Performance Information & Value*, 8(1).

Arab News. (2011, December 23). Projects worth SR550bn stalled, contractors ask government to step in. *Gulf in the Media*.

Arab News. (2014, January 4). Debate over delays in public projects. *Access World News*. http://docs.newsbank.com.ezproxy1.lib.asu.edu/openurl?ctx_ver=z39.88-2004&rft_id=info:sid/iw.newsbank.com:AWNB:SANJ&rft_val_format=info:ofi/fmt:kev:mtx:ctx&rft_dat=14B2444B657C7F20&svc_dat=InfoWeb:aggregated5&req_dat=0D0CB4EB19340F80

Assaf, S. A., & Al-Hejji, S. (2006). Causes of delay in large construction projects. *International Journal of Project Management, 24(4),* 349–357.

Banaitiene, N., & Banaitis, A. (2006). Analysis of criteria for contractors' qualification evaluation. *Technological and Economic Development of Economy*, *12*(4), 276–282.

Bedford, T. (2009). *Analysis of the low-bid award system in public sector construction procurement* (Doctoral dissertation). University of Toronto, Canada.

Capen, E. C., Clapp, R. V., & Campbell, W. M. (1971). Competitive bidding in high-risk situations. *Journal of Petroleum Technology*, *23*(6), 641–653.

CFMA's. (2006). Construction Industry Annual Financial Survey. *Moss-Adams, LLP, Eighteenth edition.*

Chan, A. P., & Chan, A. P. (2004). Key performance indicators for measuring construction success. *Benchmarking: an international journal*, *11*(2), 203-221.

Chao, L. C., & Liou, C. N. (2007). Risk-minimizing approach to bid-cutting limit determination. *Construction Management and Economics*, *25*(8), 835–843.

Cheng, C. B. (2008). Solving a sealed-bid reverse auction problem by multiple-criterion decision-making methods. *Computers & Mathematics with Applications*, *56*(12), 3261–3274.

Cordesman, A. H. (2002). Saudi Arabia enters the 21st Century: Economic, Demographic and Social Challenges. *Washington, DC: Center for Strategic and International Studies.*

Crowley, L. G., & Hancher, D. E. (1995). Risk assessment of competitive procurement. *Journal of Construction Engineering and Management, 121*(2), 230–237.

Doyle, W. J., & DeStephanis, A. (1990). Preparing bids to avoid claims. *Construction Bidding Law*, 17–45.

Egan, S.J. (1998). Rethinking Construction: The Report of the Construction Task Force to the Deputy Prime Minister, John Prescott, on the scope for improving the quality and efficiency of UK construction. *The Department of the Environment, Transport and the Regions.*

Han, S. H., Park, S. H., Kim, D. Y., Kim, H., & Kang, Y. W. (2007). Causes of bad profit in overseas construction projects. *Journal of Construction Engineering and Management*, *133*(12), 932–943.

Hatush, Z., & Skitmore, M. (1997). Evaluating contractor prequalification data: Selection criteria and project success factors. *Construction Management and Economics*, *15*(2), 129–147.

Hatush, Z., & Skitmore, M. (1997a). Criteria for contractor selection. *Construction Management & Economics*, *15*(1), 19–38.

Herbsman, Z., & Ellis, R. (1992). Multiparameter bidding system—Innovation in contract administration. *Journal of Construction Engineering and Management*, *118*(1), 142–150.

Holt, G. D., Olomolaiye, P. O., & Harris, F. C. (1994). Evaluating performance potential in the selection of construction contractors. *Engineering, Construction and Architectural Management*, *1*(1), 29–50.

Holt, G. D., Olomolaiye, P. O., & Harris, F. C. (1995). A review of contractor selection practice in the UK construction industry. *Building and Environment*, *30*(4), 553–561.

Huang, X. (2011). An analysis of the selection of project contractor in the construction management process. *International Journal of Business and Management*, *6*(3), p184.

Iyer, K. C., & Jha, K. N. (2005). Factors affecting cost performance: Evidence from Indian construction projects. *International Journal of Project Management*, *23*(4), 283–295.

Kashiwagi, D. (2010). Best Value PIPS/PIRMS. *Performance Based Studies Research Group, Kashiwagi Solution Model Inc., Mesa, AZ.*

Kashiwagi, D. (2011). Case study: Best value procurement/performance information procurement system development. *Journal for the Advancement of Performance Information & Value, 3*(1).

Kashiwagi, D. (2014). Information measurement theory with the "Kashiwagi Story." Retrieved from www.KSM-Inc.com

Kashiwagi, D., & Kashiwagi, J. (2011). Case Study: Performance Information Procurement System (PIPS) in the Netherlands. *Malaysian Construction Research Journal, 8*(1).

Koushki, P. A., Al-Rashid, K., & Kartam, N. (2005). Delays and cost increases in the construction of private residential projects in Kuwait. *Construction Management and Economics, 23*(3), 285–294.

Mahamid, I. (2013). Contributions to schedule delay in public construction projects in Saudi Arabia: Owners' perspective. *Journal of Construction Project Management and Innovation, 3*(2), 608–619.

Merna, A., & Smith, N. J. (1990). Bid evaluation for UK public sector construction contracts. *ICE Proceedings, 88*(1), p. 91–105.

Ministry of Finance. (2015, December 28). *Recent economic developments and highlights of fiscal years 1436/1437 (2015) & 1437/1438 (2016), Saudi Arabia*. Retrieved from https://www.mof.gov.sa/English/DownloadsCenter/Budget/Ministry's%20of%20Finance%20statment%20about%20the%20national%20budget%20for%202016.pdf

Moore, M. J. (1985). Selecting a contractor for fast-track projects part 1. Principles of contractor evaluation. *Plant Engineering, 39*(12), 74–75.

Ng, S. T., & Skitmore, R. M. (2001). Contractor selection criteria: A cost–benefit analysis. *IEEE Transactions on Engineering Management, 48*(1), 96–106.

Olaniran, O. J. (2015). The effects of cost-based contractor selection on construction project performance. *Journal of Financial Management of Property and Construction, 20*(3), 235–251.

PBSRG (2010). "*Performance Based Studies Research Group Internal Research Documentation," Arizona State University, Unpublished Raw Data.*

Plebankiewicz, E. (2008). Criteria of contractor selection used by Polish investors. *Journal of Civil Engineering and Management, 15*(4), 377–385.

Plebankiewicz, E. (2009). Contractor prequalification model using fuzzy sets. *Journal of Civil Engineering and Management, 15*(4), 377–385.

Plebankiewicz, E. (2010). Construction contractor prequalification from Polish clients' perspective. *Journal of Civil Engineering and Management, 16*(1), 57–64.

Price, A. D., & Al-Otaibi, M. (2010). Analysis and evaluation of criteria for pre-selecting contractors in the Saudi Arabian construction sector. IN: Egbu, C. (ed.), Proceedings 26th Annual ARCOM Conference, 6-8 Septem- ber 2010, Leeds, UK. Association of Researchers in Construction Management, Vol. 2, pp.11411148.

Sari, A., & El-Sayegh, S. (2007, May). *Factors affecting the selection of the appropriate construction management at-risk contractor.* Paper presented at the Fifth LACCEI International Latin American and Caribbean Conference for Engineering and Technology, (*LACCEI" 2007*).

Singh, D., & Tiong, R. L. (2006). Contractor selection criteria: Investigation of opinions of Singapore construction practitioners. *Journal of Construction Engineering and Management, 132*(9), 998–1008.

Waara, F., & Bröchner, J. (2006). Price and nonprice criteria for contractor selection. *Journal of Construction Engineering and Management, 132*(8), 797–804.

Wolfsetter, E. (1996). Auctions: An introduction. *Journal of Economic Surveys,* 1(4), 367–420.

Wong, C. H., Holt, G. D., & Cooper, P. A. (2000). Lowest price or value? Investigation of UK construction clients' tender selection process. *Construction Management & Economics, 18*(7), 767–774.

Zack, J. G. (1993). "Claimsmanship": Current perspective. *Journal of Construction Engineering and Management, 119*(3), 480–497.

Zain Al-Abedien, H. M. (1983). About the effect of delay penalty on the construction of projects and modification proposals. *Proceedings from the First Saudi Engineering Conference. Jeddah,* 14–19.

Exploring Company Performance Measurement for Truck Manufacturers

Qinqin Zeng, MS, and Wouter W.A. Beelaerts van Blokland, PhD
Delft University of Technology
Delft, the Netherlands

This paper aims to develop a quantitative model of company performance from an inventory perspective for truck manufacturers. With the inventory performance as a new dimension, fourteen indicators are identified to form a conceptual framework for truck manufacturers to measure their company performance. Accordingly, techniques of the fuzzy logic and the analytic network process (ANP) are used to generate the quantitative model, considering the interdependency between the indicators and the uncertainty arising from human qualitative judgments. A case study is conducted in nine truck manufacturers, with time series data from the fiscal year 2004 to 2015. The ranking result out of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is used as a validation, which proves the higher accuracy of the model developed.

Keywords: Company performance, Multi-criteria decision making, Inventory performance, Truck manufacturers.

Introduction

Originating from Toyota production system, lean production (LP) has evolved as a best-practice strategy over time and has been widely applied beyond the automotive industry. LP focuses on creating value and eliminating waste. The notion of 'value' has been increasingly emphasized under the global competitive environment. Companies regard their value creation as a main objective, thus it is necessary for companies to quantify their value-added activities' performance. The worldwide truck market can be considerably impacted by changes in politics and economy, such as the large dip during the financial crisis around the year 2009. Under the complex global competition, it is vital that truck manufacturers can adopt an effective company performance measurement, which is suitable for the specific operation and management background of the truck industry, to gauge how well they perform at adding value for their shareholders. The cost-related financial performance measurements are still being primarily relied on for company performance despite the false image of a company's situation it may present. This is due to the lack of acceptance of some novel performance measurements which are reasonable both theoretically and practically (Fatur, 2009). Besides creating value, LP also focuses on eliminating waste. Waste is defined as any human activity which absorbs resources but creates no value (Womack and Jones, 1996). Ohno has identified seven types of waste, and excess inventory is one of them. Inventory performance is commonly operationalized as inventory turnover and inventory to sale ratio (Cannon, 2008). Inventory performance is argued to be a robust indicator in company's financial performance.

This paper is structured as follows: next, a literature review is conducted on inventory performance and on company performance, both at the company level in manufacturing industry,

following a conceptual framework M of company performance measurement for truck manufacturers. And then the corresponding quantitative model V is developed, with the application of the fuzzy logic and ANP to get the weights of the measures within M. And then a case study is conducted in nine truck manufacturers, with time series data from the fiscal year 2004 to 2015. The validation of the model V is conducted by comparing its ranking result with the result from TOPSIS. Finally, the conclusions as well as the directions for future research are presented.

Literature Review

Inventory Performance

Inventory

In accounting, inventory is an important assets for a company, because the turnover of inventory represents one of the primary sources of revenue generation and the subsequent earnings for the company's shareholders (Virender, 2010). Inventory consists of three sub accounts: raw materials inventory (RMI), work-in-progress inventory (WIP) and finished goods inventory (FGI) (Michaloudis et al., 2008). RMI represents goods which is used in the production as a source material, WIP includes goods which is in the process of being transformed during manufacturing and is about to be converted into finished goods, and FGI represents products that have gone through the production and are ready for sale. LP has evolved as a powerful management strategy over time, and it has been applied in sectors like aerospace, steel mills, food, electronics, service, health care etc. Excess inventory is one type of waste within a company, which should be eliminated.

Inventory performance

Some research highlights the central role that inventory plays in companies' financial performance and employ publicly available inventory data to state that inventory has been decreasing in many manufacturing sectors with a better financial performance. It is concluded that companies with abnormally high inventories have abnormally poor long-term stock returns, and companies with slightly lower than average inventories have good stock returns, but companies with the lowest inventories have only ordinary returns. A case study was conducted in U.S. manufacturing companies (standard industrial classification codes from 2000 to 3999) during 1981 to 2000, and a linear mixed function was developed with "inventory to assets ratio" and "inventory days" as inventory measures, and "Tobin's Q", "market to book ratio" and "stock returns" as financial impact of inventories (Chen et al., 2005). Afterwards, the authors state that abnormally high and low inventory levels seem to negatively affect long-term stock price performance, adding "inventory to sales ratio" as the third inventory measure, with a portfolio method longitudinal analyses and a sample of retailers, wholesalers and manufacturers during 1981 to 2004 (Chen et al., 2007). As the first to systematically analyze the relationship between inventory performance and financial performance for a large sample of firms across all manufacturing industries, this research finds a significant positive correlation between inventory performance (total inventory, RMI, WIP and FGI) and financial performance (expressed by EBIT and gross profit). A case study was conducted in US-based manufacturing firms over the 26-year period from 1980 to 2005 by regression analysis (Capkun et al., 2009).

The relationship between the use of inventory management practices (expressed by inventory turnover) and the implementation of other manufacturing practices is studied, with 1160 manufacturing companies, by locally weighted smoothing approach and regression analysis. The results show that inventory turnover is weakly related to overall company performance (constructed from 15 descriptive measures from questionnaires) (Vastag and Whybark, 2005). It is concluded that inventory turnover does not lead to the improved company performance, with "ROA", "ROI", "market value added" and "Tobin's Q" as measures. A case study is conducted in 244 companies from the year 1991 to 2000, and the results indicate no link between improvements in inventory performance and improvements in overall firm performance, even when fundamental changes to firms' production approaches are taken into account (Cannon, 2008). It is revealed that the higher the level of inventories (expressed by inventory turnover and inventory days) preserved by a company, the lower its rate of returns (expressed by gross margin and net operating margin). A case study was conducted in Greek manufacturing companies in textile, food, and chemical industries from 2000 to 2002, and the results verified by means of pseudo-likelihood ratio test confirm the existence of a robust linear relationship but only in the chemicals sector (Koumanakos, 2008).

Company Performance Measurement

Topics about company performance and its measurement have a long history in management and accounting literature (Neely et al., 2005). For a company, it is important to have a performance measurement as you cannot manage what you do not measure (Garvin, 2009). Traditional performance measurements are regarded as "lagged" because they are "the result of management action and organizational performance, not the cause of it" (Eccles and Pyburn, 1992). In addition, the exclusive use of a limited number of financial indicators may encourage a focus on short-term results, which is not suitable in today's complex global competition environment (Fatur, 2009). Accordingly, performance measurement has been encouraged to evolve into integrated sets of both financial indicators and nonfinancial ones, such as the third generation of performance measurement system (Neely et al., 2003).

Company performance measurement techniques

Multi-criteria decision-making (MCDM) is one of the most widely used methodologies in fields like business and economy (Mardani et al., 2015). Over the last decades, several MCDM techniques have been proposed, such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Grey Relational Analysis (GRA), VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) and best-worst method (Rezaei, 2016), etc. Some researches utilize the fuzzy logic technique to evaluate and prioritize based on their financial performance for manufacturing industry (Fahami et al., 2015). Some researchers have focused on merging two or more techniques into one to overcome the shortcomings of each technique, which can increase the credibility of the assessment results. To evaluate business performance for high-tech manufacturing companies, a new set of 5 dimensions and 18 indicators is identified. An evaluation approach, consisting of the data envelopment analysis (DEA), AHP, fuzzy logic and TOPSIS, is developed and demonstrated with a case study in liquid-crystal display panel companies in Taiwan (Tseng et al., 2009). A lean dynamic model is developed based on parameters of conception, configuration and conception to measure the lean performance of

companies and can serve as a benchmarking tool (Beelaerts van Blokland et al., 2008). A framework is developed with 5 dimensions and 5 indicators for automobile sector. By the techniques of bivariate correlation analysis and multiple regression analysis, a performance index I_p is constructed and calculated to quantify companies' capabilities in creating value in 33 carmakers and 5 truck builders (Beelaerts van Blokland et al., 2010).

Research Question

Literature on company performance measurement at the company level for manufacturing sectors is listed in appendix A. The literature highlights the limited research on the effect of inventory performance on overall company performance besides financial perspective. As is shown in figure 1, LP focuses on value creation and waste reducing. Traditionally, more value created means better financial performance and better company performance, and more excess inventory (a type of waste) eliminated means better inventory performance. As to the effects of inventory performance on company performance, most of the studies just replace company performance with financial performance and suggest inventory performance acts as a trigger for financial performance, while some others consider that no relation exists between the two performances in some industries.

This paper proposes the main research question as follows: *How to quantitatively measure company performance with an inventory perspective for truck manufacturers?* Based on this main research question, two sub questions are proposed, both of which are for truck manufacturers with an inventory perspective:

RQ_1: *What indicators can be used to quantitatively measure company performance?*

RQ_2: *Can these indicators form a quantitative company performance measurement model?*

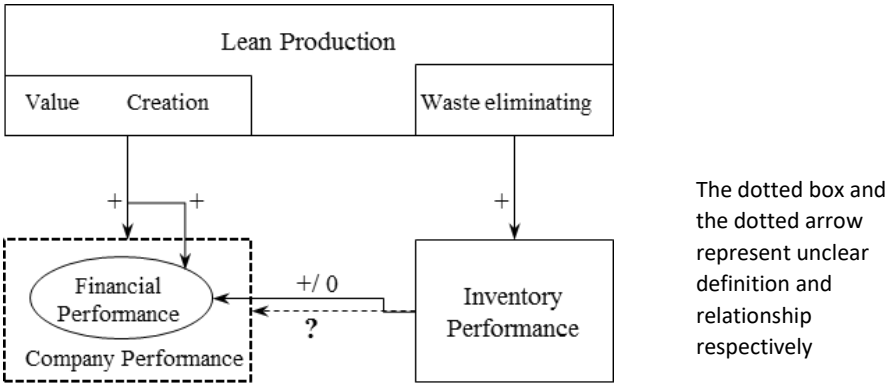


Figure 1: Framework of *LP*, company performance and inventory performance.

A Conceptual Framework

During the whole process of the company performance measurement framework for truck companies, some basic requirements are always considered:

- from both a long- term and short-term perspective;
- the performance measurement should be undertaken in ways that are easily understood by the truck companies whose performance is being evaluated;

- the performance measurement should be accomplished by a limited number of performance measures that consists of both financial and non-financial measures (Tangen, 2003).

Five Dimensions from Prior Research
From the literature, four dimensions are highlighted:

1. Competition performance.
2. Financial performance.
3. Manufacturing capability.
4. Supply chain relationships.

Besides the four dimensions, innovation capability is added for a business performance evaluation dimension in high-tech manufacturing industry (Tseng et al., 2009). Besides, referring to the researches (Beelaerts van Blokland, 2010, Beelaerts van Blokland et al., 2012), this paper proposes a new conceptual company performance measurement framework M for truck manufactures. Instead of the dimension "innovation capability" for high-tech industry, this paper takes "technology performance" considering truck a manufacturing sector does get more sensitive to the technologies.

Inventory Performance as an Original Dimension
Inventory turnover. It reflects the overall efficiency of the supply chain, from suppliers to customers (Rabinovich et al., 2006). Inventory turnover (INT) can be calculated as sales divided by average inventory, and it is also can be calculated as the cost of goods sold (COGS) divided by average inventory. Both calculations can be available for the total inventory as well as its three sub accounts. Because sales include a mark-up over cost, the former calculation inflates inventory turnover. Thus, for higher accuracy, in this paper, inventory turnover is calculated as in equation (1), where *I* for inventory size, *t* and *t-1* for the fiscal year *t* and the fiscal year *t-1* respectively.

$$INT_t = COGS_t / \left[0.5*(I_t + I_{t-1})\right] \quad (1)$$

Inventory efficiency. This paper adopts inventory to sales ratio (ITSR) for inventory efficiency, which measures the percentage of inventories the company currently has on hand to support the current amount of net sales. Traditionally, an increasing ITSR is a negative sign, showing the company may be in trouble keeping inventory down. Viewing this ratio over several time periods reveals the important aspect of the company's ability to manage inventories while attempting to increase sales. It is important to compare their ratios to industry averages. In this paper, ITSR is calculated as in equation (2), where *GS for* Gross Sales.

$$ITSR_t = \left[0.5*(I_t + I_{t-1})\right] / NS_t \quad (2)$$

A conceptual framework M
To answer RQ_1, a conceptual framework M is developed for truck manufacturers to measure their company performance. As is shown in table 1, M consists of six dimensions, fourteen indicators and their measures.
Table 1: The conceptual framework M of company performance for truck companies.

Dimension	Indicator	Measure	Reference(s)
Competition performance (CP)	C_1Sales	Sales turnover (*T*) [$]	Doyle and Hooley, 1992, Simatupang and Sridharan, 2005
	C_2Market share	Market share(*MS*) [%]	Kozmetsky and Yue, 1998, Govindarajan and Gupta, 1985
Financial performance (FP)	C_3Profitability	Net profit margin (*NM*) [%]	Doyle, 1994, Sinkey and Nash, 1993, Hsu, 2015
	C_4Market capitalization	Market capitalization (*MC*) [$]	Low, 2000, Shiu, 2006, Tseng et al., 2009
	C_5Financial leverage	Financial leverage ratio (*FLR*) [%]	Ertuğrul and Karakaşoğlu, 2009, Murphy et al., 1996
	C_6Cash flow margin	Operating cash flow margin ratio(*OCFR*) [%]	Volpe, 2017, Chandler and Hanks, 1993, Tan, 2002
Manufacturing capability (MC)	C_7Productivity	Trucks produced per employee (T_p/ *E*) [#]	Brignall et al., 1991, Laitinen, 2002
	C_8Continuity	Profit per employee (*P*/*E*) [$]	Beelaerts van Blokland, 2010, Bryan, 2007
Technology performance (TP)	C_9Conception	R&D expenditure per employee (*R&D* /*E*) [$]	Keeble and Walker, 1994
	C_{10}R&D efficiency	R&D expenditure per profit (*R&D* /*P*) [%]	Beelaerts van Blokland et al., 2010
Supply chain relationship (SCR)	C_{11}Profit leverage	Profit leverage ratio (*T*/ *P*) [%]	Beelaerts van Blokland et al., 2010
	C_{12}Configuration	Turnover per employee (*T*/ *E*) [$]	Beelaerts van Blokland et al., 2012, Clark et al., 1995
Inventory performance (IP)	C_{13}Inventory turnover	Inventory turnover (*INT*)	Vastag and Whybark 2005
	C_{14}Inventory efficiency	Inventory to sales ratio (*ITSR*)	Chen et al., 2007, Capkun et al., 2009

Methodology

To answer RQ_2, an approach is developed for obtaining the quantitative function, including techniques of fuzzy logic, *ANP*. This paper refers to matrix manipulation approach (Saaty and Takizawa, 1986) to demonstrate its easy-to-understand in calculating the weights by ANP. A case study is conducted in nine leading truck manufacturers from the fiscal year 2004 to 2015.

Fuzzy logic

To handle the inherent subjectivity and incompletely defined data, this paper adopts the fuzzy set theory, also referred as fuzzy logic (Werro, 2016). As a mathematical theory first introduced by Zadeh in 1965, its key idea is that an element has a degree of membership in a fuzzy set which is defined by a membership function (Taha and Rostam, 2011). The fuzzy set can be $\tilde{a}=\{(x, \mu_{\tilde{a}}(x)), x \in R, \mu_{\tilde{a}}(x) \in [0, 1]\}$, where x is a point in the universe, $\mu_{\tilde{a}}$ for the membership function of $\tilde{a}$, and $\mu_{\tilde{a}}(x)$ for the degree of x attributed to $\tilde{a}$. The membership function can be the trapezoidal function, the triangular membership function etc. Each fuzzy set corresponds to a linguistic variable, such as those associated with the nine-point scale by Saaty. This paper adopts the triangular membership function in equation (3) due to its computational simplicity for decision makers (Moon and Kang, 2001), where a^l, a^m and a^u denote the smallest possible value, the most promising value, and the largest possible value respectively, and $a^l \leq a^m \leq a^u$.

$$\mu_{a}(x)=\begin{cases}(x-d^{l})/(a^{m}-d^{l}), & d^{l}\le x\prec a^{m}\\ 1, & x=a^{m}\\ (a^{u}-x)/(a^{u}-a^{m}), & a^{m}\prec x\le a^{u}\\ 0, & otherwise\end{cases} \quad (3)$$

ANP technique

It is stated that *AHP* ranked as the most frequently used *MCDA* technique in 2013 (Mardani et al., 2015). As its extension in solving *MCDA* problems, *ANP* allows dependency between factor and is more suitable to the realistic problems when being compared with *AHP* (Saaty, 2004). As is demonstrated in figure 2, there exists inner dependence within the six dimensions and fourteen indicators in this research. Thus, this paper adopts *ANP* to calculate the weights of the indicators.

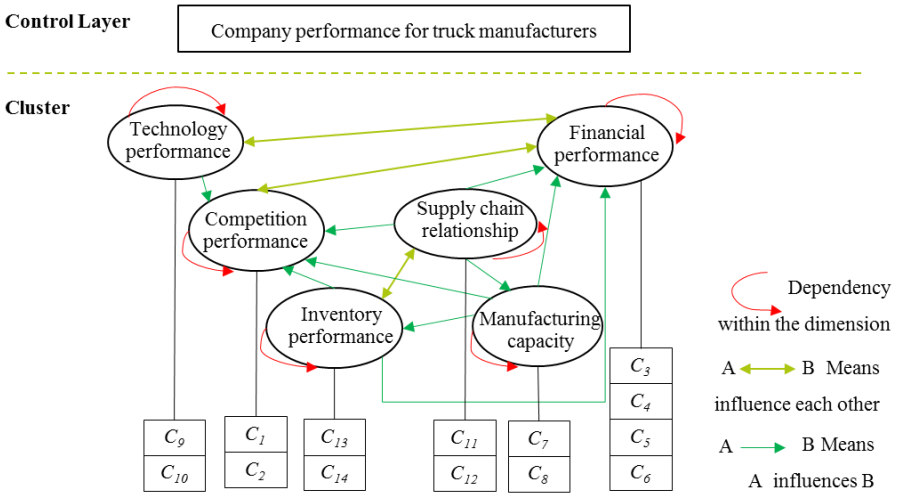


Figure 2: The structure of company performance for truck manufacturers.

According to *ANP*, the supermatrix with its sub-matrix notation for the conceptual framework M can be constructed in equation (4), where w_1 is a vector that represents the impact of the control criterion on the cluster, namely, the impact of "company performance" on the six dimensions; W_2 is a matrix with inner dependence between the six dimensions; W_3 is a matrix that denotes the impact of the dimensions on the indicators; and W_4 is a matrix with the impact of the indicators on each alternative, and I is the identity matrix. This research aims to calculates the weights of indicators on company performance.

$$W=\begin{bmatrix}0 & 0 & 0 & 0\\ w_1 & W_2 & 0 & 0\\ 0 & W_3 & 0 & 0\\ 0 & 0 & W_4 & I\end{bmatrix} \quad (4)$$

Fuzzy ANP

The steps for using fuzzy ANP to quantify company performance is as follows:

Step 1. Construct the ANP structure hierarchically with control layer, dimensions, and indicators.

Step 2. Construct the pairwise comparison matrices *A*, via experts' judgements and their linguistic variables (Ayağ and Samanlioglu, 2016, Saaty, 1989) and their corresponding importance levels from 1st and 2nd columns in table 2.

Table 2: The linguistic variables and their corresponding fuzzy numbers.

Linguistic variable	***Importance levels***	***Fuzzy number***	***Membership function***	$\left[a_\alpha^l, a_\alpha^u\right]$
Equal importance	1	$\tilde{1}$	(1,1,2)	[1,3-2α]
Moderate importance	3	$\tilde{3}$	(2,3,4)	[1+2α,5-2α]
Essential importance	5	$\tilde{5}$	(4,5,6)	[3+2α,7-2α]
Very strong importance	7	$\tilde{7}$	(6,7,8)	[5+2α,9-2α]
Extreme importance	9	$\tilde{9}$	(8,9,10)	[7+2α,11-2α]
Intermediate impantance	2,4,6,8			

Step 3. Construct the fuzzy pairwise comparison matrices $\tilde{A}$ and get it reconstructed with crisp values, as in equation (5) and (8) respectively. 1) Replace the crisp importance levels in *A* with the corresponding triangular fuzzy numbers from 3rd column in table 3, where reciprocal values are automatically assigned to the reverse comparison; 2) denote α as the confidence level, $\forall\alpha \in [0,1]$, $a_\alpha = \{x \mid \mu_{\tilde{a}}(x) \geq \alpha\}$ as α - cut set, and calculate α - cut fuzzy comparison matrix with equation (6) (Taha and Rostam, 2011); 3) set the index of optimism μ, which expresses the degree of satisfaction for the judgement matrix $\tilde{A}$, $\forall\mu \in [0, 1]$, and calculate the elements $a_{ij,\alpha}$ with the equation (7). In this paper, *j* and p (*j, p =1, 2..., n, and j*≠ p) represent for the individual indicators for company performance measurement.

$$\tilde{A}=\begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & 1 \end{bmatrix}=\begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{12}^{-1} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{1n}^{-1} & a_{2n}^{-1} & \dots & 1 \end{bmatrix} \quad \textbf{(5)}$$

$$a_\alpha=\left[a^l, a^u\right]=\left[\alpha\left(a^m-a^l\right)+a^l, -\alpha\left(a^u-a^m\right)+a^u\right] \quad \textbf{(6)}$$

$$a_{jp,\alpha}=\mu a_{jp,\alpha}^u+(1-\mu)a_{jp,\alpha}^l \quad \textbf{(7)}$$

$$A_\alpha=\begin{bmatrix} 1 & a_{12,\alpha} & \dots & a_{1n,\alpha} \\ a_{21,\alpha} & 1 & \dots & a_{2n,\alpha} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1,\alpha} & a_{n2,\alpha} & \dots & 1 \end{bmatrix}=\begin{bmatrix} 1 & a_{12,\alpha} & \dots & a_{1n,\alpha} \\ a_{12,\alpha}^{-1} & 1 & \dots & a_{2n,\alpha} \\ \vdots & \vdots & \ddots & \vdots \\ a_{1n,\alpha}^{-1} & a_{2n,\alpha}^{-1} & \dots & 1 \end{bmatrix} \quad \textbf{(8)}$$

Step 4. Verify (and revise) the consistency of the comparison matrices and calculate the weights of the sub-matrix in equation (4). 1) For each comparison matrix, verify the consistency ratio (*CR*) as *CI /RI*, where *CI* is the consistency index in equation (9), $\boldsymbol{\lambda_{max}}$ is the maximum eigen value of the matrix, and *RI* is the

random index whose values had been assigned by *Satty* in 2001. All the *CR* values must be less than 0.10, which means the judgments are consistent enough to be acceptable, otherwise the comparison matrix should be revised; 2) calculate the vector w_1 and the matrix W_3, with assumption that there is no dependence between the six dimensions or between the fourteen indicators; 3) similarly, the step 2 and step 3 for the indicators and calculate the sub-matrix W_2.

$$CI=(\lambda_{max}-n)/n-1 \quad (9)$$

Step 5. Calculate the interdependent priorities of the dimensions as $w_d = w_1 \times W_2$, and finally calculate and normalize the weights of the indicators on company performance as the vector $w= W_2 \times w_1 \times W_3$, $w \in (0,1)$.

Step 6. Construct a decision matrix $B_{m \times n}$ and normalize the elements with the procedure in equation (10), where i ($i=1,2,...,m$) represents for the alternative truck manufacturers, x_{ij}^t for the value of indicator j on alternative i at fiscal year t ($t=0,1,...,T$), x^{*t}_{ij} for the normalized value of x_{ij}^t, and $x^*{}_{ij}{}^t \in (0,1]$.

$$x^{*t}_{ij}=\begin{cases}\dfrac{x_{ij}^t}{\max\limits_i x_{ij}^t} & \text{if } x_{ij}^t \text{ satisfies "the larger the better" category}\\ \dfrac{\min\limits_i x_{ij}^t}{x_{ij}^t} & \text{if } x_{ij}^t \text{ satisfies "the smaller, the better" category}\end{cases} \quad (10)$$

Step 7. Aggregate and calculate the values for the nine companies as equation (11), where P_i^t is the index of company performance for truck manufacturers i at fiscal year t, and $I_i^t \in (0,1)$.

$$P_i^t=\sum x_{ij}^{*t} * w_j \quad (11)$$

Analysis

To demonstrate the applicability of the approach proposed, a case study is conducted in nine influential truck manufacturers. As is listed in table 3, they are from Europe, America and Asia, and account for more than 51.7% percent of the total global vehicle production volume in 2015 (source: *IHS* Automotive, *KPMG* International). Yearly data is mainly collected from public available annual reports, and the currency is adjusted in US dollars for comparability. The period is from the fiscal year 2004 to 2015, which is the largest time span, since all the 9 sample companies had been listed with complete data for the research since 2004, and reports in 2016 are not available at the time of this paper.

Table 3: List of the nine sample truck manufacturers.

Name	Identifier	Country	Name	Identifier	Name	Identifier	Country
Daimler	*DAI*	Germany	Volvo	*VOL*	*CNHTC*	*CNH*	China
MAN	*MAN*	Germany	Navistar	*NAV*	Dongfeng	*DFG*	China
Scania	*SCA*	Sweden	Paccar	*PAC*	Ashok Leyland	*ASH*	India

The company performance measurement function V

According to the steps mentioned above, the steps for using fuzzy ANP to develop the quantitative company performance measurement function V is as follows:

Step 1. Construct the schematic structure as is demonstrated in figure 2.

Step 2. Construct the pairwise comparison matrices for the six dimensions and the fourteen indicators, assuming no dependency, and for the six dimensions assuming dependency, with respect to company performance, respectively. All the comparison matrices are filled up based on a questionnaire of pairwise comparison (appendix B) and the average scores of judgements by five industry professionals. Take the pairwise comparison for the six dimensions assuming no dependence for example, the result is shown in table 4.

Table 4: The pairwise comparison A_1 of dimensions assuming no dependency among them.

Dimension	CP	FP	MC	TP	SCR	IP
CP	1	1	5	1	1	3
FP	1	1	3	1	7	3
MC	1/5	1/3	1	3	1	3
TP	1	1	1/3	1	1	5
SCR	1	1/7	1	1	1	3
IP	1/3	1/3	1/3	1/5	1/3	1

Step 3. Construct the fuzzy pairwise comparison matrices and get it reconstructed with crisp values. in table 6. 1) Replace the crisp importance levels in *A* with the corresponding triangular fuzzy numbers in table 5; and 2) calculate the elements $a_{ij,\alpha}$ for α =0.5 and μ =0.5.

Table 5: The fuzzy numbers and $a_{ij,\alpha}$ values for A_1.

Dimension	CP	FC	MC	TP	SCR	IP	Eigenvector	w_1
CP	1	1, 1.5	5, 5	1, 1.5	3, 3	3, 3	-0.615	0.284
FC	1^{-1}, 0.75	1	3, 3	1, 1.5	7, 7	3, 3	-0.616	0.284
MC	5^{-1}, 0.208	3^{-1}, 0.375	1	3, 3	1, 1.5	3, 3	-0.321	0.148
TP	1^{-1}, 0.75	1^{-1}, 0.75	3^{-1}, 0.375	1	1, 1.5	5, 5	-0.290	0.134
SCR	1^{-1}, 0.75	7^{-1}, 0.146	1^{-1}, 0.75	1^{-1}, 0.75	1	3, 3	-0.202	0.093
IP	3^{-1}, 0.375	3^{-1}, 0.375	3^{-1}, 0.375	5^{-1}, 0.208	3^{-1}, 0.375	1	-0.122	0.056

RI=1.24; λ_{max}= 6.9046; CR=0.0809

Step 4. Verify the consistency of the comparison matrices and calculate the weights of the sub-matrix. As is shown in table 6, the weights of the six dimensions with respect to company performance assuming no dependency among them is shown in calculated as w_1, with *CI* value is less than 0.10. Similarly, do the step 2 to step 4 for the six dimensions assuming dependency among them to get W_2, and for the fourteen indicators to get W_3, with respect to company performance.

$$W_2' = \begin{bmatrix} 1.000 & 0.311 & 0.255 & 0.655 & 0.269 & 0.127 \\ 0.212 & 1.000 & 0.441 & 0.345 & 0.352 & 0.322 \\ 0.295 & 0.096 & 1.000 & 0.000 & 0.211 & 0.341 \\ 0.174 & 0.214 & 0.000 & 1.000 & 0.000 & 0.000 \\ 0.132 & 0.359 & 0.121 & 0.000 & 1.000 & 0.210 \\ 0.187 & 0.021 & 0.183 & 0.000 & 0.168 & 1.000 \end{bmatrix},$$

$$W_3' = (0.465, 0.534, 0.211, 0.325, 0.319, 0.145, 0.601, 0.389, 0.549, 0.450, 0.299, 0.701, 0.698, 0.302)^T$$

Step 5. Calculate the interdependent priorities of the dimensions w_d, calculate and normalize the weights of the indicators on company performance w.

$$w_d = W_2' \times w_1' = \begin{bmatrix} 1.000 & 0.311 & 0.255 & 0.655 & 0.269 & 0.127 \\ 0.212 & 1.000 & 0.441 & 0.345 & 0.352 & 0.322 \\ 0.295 & 0.096 & 1.000 & 0.000 & 0.211 & 0.341 \\ 0.174 & 0.214 & 0.000 & 1.000 & 0.000 & 0.000 \\ 0.132 & 0.359 & 0.121 & 0.000 & 1.000 & 0.210 \\ 0.187 & 0.021 & 0.183 & 0.000 & 0.168 & 1.000 \end{bmatrix} \times \begin{bmatrix} 0.284 \\ 0.284 \\ 0.148 \\ 0.134 \\ 0.093 \\ 0.056 \end{bmatrix} = \begin{bmatrix} 0.530205 \\ 0.507141 \\ 0.298183 \\ 0.244152 \\ 0.262558 \\ 0.158045 \end{bmatrix}$$

$$w = (0.123, 0.142, 0.054, 0.083, 0.081, 0.037, 0.090, 0.058, 0.067, 0.055, 0.039, 0.092, 0.055, 0.024)^T$$

Step 6. Construct a matrix $B_{m \times n}$ with the normalized values of the indicators for each of the nine sample truck manufacturers during the fiscal year 2004 to 2015.

Step 7. Generate the quantitative function of company performance P_i^t for each truck manufacturer.

$$V = f\left[x_j^{*t}, w_j\right] = \sum x_j^{*t} * w_j = 0.123T + 0.142MS + 0.054NM + 0.083MC + 0.081FLR + 0.037OCFR + 0.090T_p / E + 0.058P / E + 0.067R\&D / E + 0.055R\&D / P + 0.039T / P + 0.092T / E + 0.055INT + 0.024ITSR$$

Validation of the function

To highlight the influence of inventory factor on the company's performance, this research also generated function 12 indicators, namely excluding inventory turnover and inventory to sales ratio indicators. Similar questionnaire survey is carried on excluding the *two inventory indicators*, and fuzzy *ANP* is used again for generating its function as follows:

$$V' = f\left[x_j^{*t}, w_j\right] = \sum_{j=1}^{12} x_j^{*t} * w_j = 0.061T + 0.126MS + 0.095NM + 0.047MC + 0.039FLR + 0.031OCFR + 0.2T_p / E + 0.113P / E + 0.055R\&D / E + 0.074R\&D / P + 0.096T / P + 0.063T / E$$

Comparison with the result from TOPISIS

After determining the model for company performance V, we need to prove its validity in the ranking by comparing its ranking result with the result of *TOPSIS* technique. The underlying logic of *TOPSIS* is to define both the ideal solution and the negative ideal sets. The ideal set is the collection that maximizes the benefit indicators and minimizes cost indicators, while the negative ideal set maximizes cost and minimizes benefit (Marler and Arora, 2004). The manufacturer with the best performance is closest to the ideal solution and farthest from the negative ideal solution. TOPSIS is a frequently used ranking method.

In this paper, the required data of all the nine sample truck companies in 2015 is taken as an example to show the detailed calculation for the coefficient of similarity to the ideal set in TOPSIS. The steps are as follows:

Step 1. Assemble the evaluation matrix $X=\left\lfloor x_{ij} \right\rfloor_{14\times 9}$ with the 14 indicators and 9 truck manufacturers and normalize the matrix $R=\left\lfloor r_{ij} \right\rfloor_{14\times 9}$, where $r_{ij}=x_{ij}/\sqrt{\sum_{i=1}^{9} x_{ij}^2}$.

$$R=\begin{bmatrix} 0.0095 & 0.9540 & \cdots & 0.1145 & 0.8959 \\ 0.0196 & 0.9788 & \cdots & 0.1175 & 0.0881 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0.3100 & 0.1585 & \cdots & 0.5305 & 0.1171 \\ 0.2312 & 0.3817 & \cdots & 0.1021 & 0.5376 \end{bmatrix}$$

Step 2. Calculate the ideal set $A^{+}=\left\{t_i^{+} \middle| \max_j t_{ij}\left(benefit\right)\&\min_j t_{ij}\left(cost\right)\right\}$ and the negative ideal set $A^{-}=\left\{t_i^{-} \middle| \min_j t_{ij}\left(benefit\right)\&\max_j t_{ij}\left(cost\right)\right\}$.

$$A^{+}=(0.458,0.949,0.728,0.315,0.172,0.197,1.321,0.685,0.264,0.605,0.641,0.301,0.008,0.204)\times 10^{-1}$$
$$A^{-}=(0.053,0.006,-0.152,0.001,-0.524,-0.163,0.836,-0.960,0.054,-1.510,-3.331,0.541,7.996,0.882)\times 10^{-2}$$

Step 3. Calculate the distance for each company to the ideal set $S^{+}=\sqrt{\sum_{i=1}^{14}\left(t_{ij}-t_i^{+}\right)^2}$ and negative ideal set $S^{-}=\sqrt{\sum_{i=1}^{14}\left(t_{ij}-t_i^{-}\right)^2}$.

$$S^{+}=(0.1809,0.1647,0.2207,0.1935,0.1660,0.1750,0.1856,0.1814,0.1872)$$
$$S^{-}=(0.0872,0.1490,0.0644,0.0970,0.1357,0.1356,0.0971,0.1032,0.1469)$$

Step 4. Calculate the similarity for each company to the ideal set.

$$C=(0.325,0.475,0.226,0.334,0.450,0.437,0.343,0.363,0.440).$$

With calculated results of the coefficient of similarity to ideal set in TOPSIS, V' and V the ranking is shown in table 6:

- TOPSIS: 1.Daimler, 2.CNHTC, 3.MAN, 4.DFG, 5.PACCAR, 6.Volvo, 7.Scania, 8.Ashok Leyland, 9.Navstar.
- V': 1.Daimler, 2. DFG, 3.CNHTC, 4.PACCAR, 5.MAN, 6.Volvo, 7.Ashok Leyland, 8.Scania, 9.Navstar.
- V: 1.Daimler, 2.CNHTC, 3.MAN, 4. Volvo, 5.PACCAR, 6. DFG, 7.Scania, 8.Ashok Leyland, 9.Navstar.

It is obvious that the ranking result from company performance model *V* (taking the inventory performance dimension into account) and the *TOPSIS* approach are very similar compared with the result from the function excluding inventory indicators. The result indicates the rationality of adding inventory performance into company performance measurement.

Table 6: Company performance measurement of the nine sample truck companies in 2015.

	w	ASH	DAI	NAV	SCA	CNH	DFG	VOL	PAC	MAN
CP		0.008	0.265	0.014	0.018	0.022	0.029	0.044	0.029	0.025
Priority		9	1	8	7	6	3	2	4	5
C1	0.123	0.013	1.000	0.062	0.069	0.018	0.120	0.228	0.118	0.092
C2	0.142	0.046	1.000	0.047	0.069	0.142	0.103	0.112	0.101	0.097
FP		0.046	0.143	-0.018	0.125	0.155	0.044	0.127	0.082	0.149
Priority		6	3	9	8	1	7	4	5	2
C3	0.054	0.050	0.090	-0.020	0.410	1.000	0.200	0.420	0.120	0.020
C4	0.083	0.010	0.780	0.080	0.000	0.030	0.010	0.090	0.520	1.000
C5	0.081	0.560	0.910	-0.300	0.850	0.760	0.400	1.000	0.290	0.740
C6	0.037	-0.080	0.000	0.010	0.910	1.000	0.010	0.430	0.230	0.140
MC		0.095	0.054	0.034	0.034	0.071	0.175	0.044	0.107	0.012
Priority		3	5	7	7	4	1	6	2	9
C7	0.090	1.000	0.140	0.470	0.140	0.720	1.760	0.200	0.540	0.110
C8	0.058	0.090	0.720	-0.140	0.370	0.110	0.290	0.450	1.000	0.030
TP		0.002	0.070	0.035	0.043	0.018	0.010	0.059	0.029	0.097
Priority		9	2	5	4	7	9	3	6	1
C9	0.067	0.020	1.000	0.730	0.590	0.210	0.140	0.820	0.420	0.620
C10	0.055	0.010	0.060	-0.250	0.070	0.080	0.020	0.080	0.020	1.000
SCR		0.029	0.067	0.058	0.030	0.053	0.019	0.050	0.095	0.069
Priority		8	3	4	7	5	9	6	1	2
C11	0.039	0.230	0.080	-0.520	0.070	0.330	0.050	0.090	0.080	1.000
C12	0.092	0.220	0.690	0.850	0.300	0.440	0.180	0.500	1.000	0.330
IP		0.035	0.030	0.032	0.031	0.012	0.062	0.030	0.047	0.033
Priority		6	7	5	6	9	1	8	2	4
C13	0.055	0.450	0.230	0.360	0.180	0.010	1.000	0.260	0.770	0.170
C14	0.024	0.430	0.710	0.500	0.860	0.490	0.310	0.640	0.190	1.000
V’		0.279	0.488	0.104	0.246	0.409	0.466	0.306	0.390	0.350
Ranking		7	1	9	8	3	2	6	4	5
V		0.215	0.629	0.155	0.281	0.333	0.340	0.354	0.388	0.385
Ranking		8	1	9	7	2	6	4	5	3
C from TOPSIS		0.325	0.475	0.226	0.334	0.450	0.437	0.343	0.363	0.440
Ranking		8	1	9	7	2	4	6	5	3

Discussion

With the company performance measurement framework M and V this paper proposes, each of the 9 sample truck companies’ company performance during the years 2004 - 2015 can be calculated and compared. In this section, V over time for each of the 9 sample companies is shown. To give a direct and better insight in the competitiveness, this paper makes each of the nine companies’ company performance plotted over time in figure 5. All the nine sample truck companies’ data is normalised at the beginning year 2004.

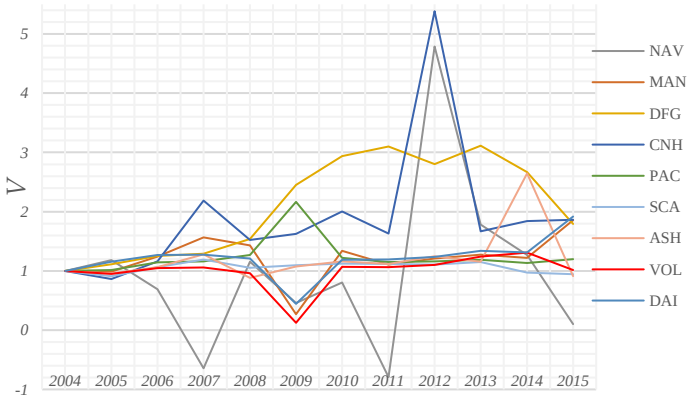


Figure 4: Values of V over time for each truck company.

In this graph, it is visible that for most of the companies, there was a peak in 2007 and after that they suffered, with a downward trend of their performance, which can be explained by the economic crisis between 2008 and 2009. In 2010, some truck companies revived, and the performance indicator increased due to the rapid economic recovery. Nevertheless, most of the truck companies' company performances remained below those of their pre-crisis, and the performance appears to have stabilized around 2013.

The highest performer over time obviously is Dongfeng, with CNHTC the second. Given the fact that Dongfeng and CNHTC are Chinese truck companies, they operate in one of the emerging BRIC countries with an increasing demand for transport of goods for new infrastructure projects, which easily leads to higher demand for trucks production. As two of the four most influential truck companies in China, Dongfeng and CNHTC are famous for their effort on independent research and development activities. The self-developed trucks like Tianlong and co-developed trucks like Jialong and HOWO, are environmental-friendly and cost-effective, and are becoming popular beyond China, contribute a lot to their better company performance. With trucks' extensive scrappage subsidy policy from the year 2009, the two companies have been pushed with the renewal of their older truck fleet. Around the year 2011, the V value of the two companies shrunk because of the negative domestic economic recession in China.

The two worst performers, Navistar and Shock Leyland, had almost all V values under 1.5 every year. For Shock Leyland, a higher company performance is expected, due to its influential position in the truck industry, however, according to its performance, it is underperforming. As reflected on the data set and the variables for the function V, the main reason for the poor performance may be that it has a larger number of employees, which makes variables like R&D expenditure per employee less, or maybe employees are not able to work very effectively by some policies, leading to the comparative low V value. As to the poor performance of Navistar, from the model and its relevant data, it was mainly caused by the unstable profitability, probably caused by the reduction of military sales and the shrinkage of demand of engines in South America. The other five companies, Paccar, Volvo, MAN, Daimler, and Scania are with average performance, normally with their V value > 1 respectively.

Conclusion & Further Research

This paper gives insight into the following research question for truck manufacturers: the quantitative measurement of company performance with an inventory perspective. First, with literature review on company performance and inventory performance, this paper proposes a new conceptual framework of performance measurement, with inventory performance as a new dimension, for truck manufacturers, which leads to the answer to RQ_1. Second, this paper adopts the fuzzy *ANP* technique, for generating mathematic functions. Third, the *TOPSIS* technique is adopted to rank the 9 truck manufacturers. The comparisons of its result and the functions' results, indicate the rationality of adding inventory performance into company performance measurement. This gives the answer to RQ_2.

This research gave an insight on quantifying company performance measurement with an inventory perspective for truck manufacturers. To get a better understanding, more research within and beyond the truck industry should be done. This paper is limited to data available in public databases and includes only publicly listed truck manufacturers over the 2004-2015 sample period. The data set can be extended by considering more truck manufacturers and by covering more years. This the research can also be extended to a broader level by researching other unexploited fields and to see how their inventory performance affects company performance.

Acknowledgements

The authors would like to thank the anonymous reviewers for their helpful comments that helped improve the content of the paper. We also would like to acknowledge the funding from China Scholarship Council (No.201506050009).

References

Ayag, Z. & Samanlioglu, F. 2016. An intelligent approach to supplier evaluation in automotive sector. *Journal of Intelligent Manufacturing,* 27**,** 889-903.

Beelaerts van blokland, W. 2010. Value-leverage by Aerospace Original Equipment Manufacturers. *Graphicom*.

Beelaerts van blokland, W., Elferink, N. & Van der zwan, F. Setting up a Company Performance Measurement Methodology for the Aerospace Industry: Deduction from the Automotive Industry. 10th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference, Fort Worth, Texas, 13-15 September 2010; AIAA 2010-9110, 2010. American Institute of Aeronautics and Astronautics (AIAA).

Beelaerts van blokland, W., Fiksinski, M., Amoa, S., Santema, S., Van silfhout, G.-J., Maaskant, L., MORITA, M., MACHUCA, J. A., FLYNN, B. & MATSUO, H. 2012. Measuring value-leverage in aerospace supply chains. *International Journal of Operations & Production Management,* 32**,** 982-1007.

Beelaerts van blokland, W., Verhagen, W. J. & Santema, S. C. 2008. The effects of co-innovation on the value-time curve: quantitative study on product level. *Journal of business market management,* 2**,** 5-24.

Cannon, A. R. 2008. Inventory improvement and financial performance. *International Journal of Production Economics,* 115**,** 581-593.

Capkun, V., Hameri, A. P. & Weiss, L. A. 2009. On the relationship between inventory and financial performance in manufacturing companies. *International Journal of Operations & Production Management,* 29**,** 789-806.

Chen, H., Frank, M. Z. & Wu, O. Q. 2005. What Actually Happened to the Inventories of American Companies Between 1981 and 2000? *Management Science,* 51**,** 1015-1031.

Chen, H., Frank, M. Z. & Wu, O. Q. 2007. US retail and wholesale inventory performance from 1981 to 2004. *Manufacturing & Service Operations Management,* 9**,** 430-456.

Eccles, R. G. & Pyburn, P. J. 1992. Creating a comprehensive system to measure performance. *Strategic Finance,* 74**,** 41.
Fahami, N. A., Rahim, Z. H. A., Azhar, F. W. & Karim, H. A. 2015. FUZZY LOGIC APPLICATION IN EVALUATING FINANCIAL PERFORMANCE: A CASE STUDY OF SERVICES SECTOR IN MALAYSIA. *Australian Journal of Business and Economic Studies,* 1.
Fatur, P. 2009. The development of a performance measurement methodology for idea management. *International Journal of Innovation & Learning,* 6**,** 422-437.
Garvin, D. A. 2009. Building a learning organization. *Phi Delta Kappan,* 82**,** 744-747.
Koumanakos, D. P. 2008. The Effect of Inventory Management on Firm Performance. *International Journal of Productivity & Performance Management,* 57**,** 355-369.
Mardani, A., Jusoh, A., Md nor, K., Khalifah, Z., Zakwan, N. & Valipour, A. 2015. Multiple criteria decision-making techniques and their applications–a review of the literature from 2000 to 2014. *Economic Research-Ekonomska Istraživanja,* 28**,** 516-571.
Marler, R. T. & Arora, J. S. 2004. Survey of multi-objective optimization methods for engineering. *Structural and multidisciplinary optimization,* 26**,** 369-395.
MichaloudisI, C., MichaloudisI, C. & Georgiadi, P. 2008. The efficiency of alternative control mechanisms in a MTO three-stage tandem production/inventory system.
Moon, J. H. & Kang, C. S. 2001. Application of fuzzy decision making method to the evaluation of spent fuel storage options. *Progress in nuclear energy,* 39**,** 345-351.
Neely, A., GREGORY, M. & PLATTS, K. 2005. 'Performance Measurement System Design: A Literature Review and Research Agenda'. *International Journal of Operations & Production Management,* 25**,** 1228-1263.
Neely, A., MARR, B., ROOS, G., PIKE, S. & GUPTA, O. 2003. Towards the third generation of performance measurement. *Controlling,* 15**,** 129-136.
Rabinovich, E., Dresner, M. E. & Evers, P. T. 2006. Assessing the effects of operational processes and information systems on inventory performance. *Journal of Operations Management,* 21**,** 63-80.
Rezaei, J. 2016. Best-worst multi-criteria decision-making method: Some properties and a linear model. *Omega,* 64**,** 126-130.
Saaty, T. L. 1989. Decision making, scaling, and number crunching. *Decision Sciences,* 20**,** 404-409.
Saaty, T. L. 2004. Decision making—the analytic hierarchy and network processes (AHP/ANP). *Journal of systems science and systems engineering,* 13**,** 1-35.
Saaty, T. L. & Takizawa, M. 1986. Dependence and independence: From linear hierarchies to nonlinear networks. *European journal of operational research,* 26**,** 229-237.
Taha, Z. & Rostam, S. 2011. A fuzzy AHP–ANN-based decision support system for machine tool selection in a flexible manufacturing cell. *The International Journal of Advanced Manufacturing Technology,* 57**,** 719.
Tangen, S. 2003. An overview of frequently used performance measures. *Work study,* 52**,** 347-354.
Tseng, F. M., Chiu, Y. J. & Chen, J. S. 2009. Measuring business performance in the high-tech manufacturing industry: A case study of Taiwan's large-sized TFT-LCD panel companies ☆. *Omega,* 37**,** 686-697.
Vastag, G. & Whybark, D. C. 2005. Inventory management: Is there a knock-on effect? *International Journal of Production Economics,* 93**,** 129-138.
Virender, S. 2010. *Production And Operations Management,* Gyan Publishing House.
Werro, N. 2016. *Fuzzy classification of online customers,* Springer.
Womack, J. P. & Jones, D. T. 1996. Beyond Toyota: how to root out waste and pursue perfection. *Harvard business review,* 74**,** 140-&.

Appendix A

Literature of company performance measurement on company level in manufacturing industry.

Author(s)	***KPI***	***Content***
Power sector Vincent and Hu, 2010	*Productivity*: average monthly ratio; *production amount*: production amount; production cost: raw materials cost, direct labor cost and factory overhead; *inventory amount*: raw material amount, *WIP* amount and finished good amount; *quality cost*: internal failure cost, external failure cost and prevention cost.	For manufacturing capability; in a switch power manufacturer; with voting method, with fuzzy logic and *TOPSIS*.
Li and Zhao, 2016	*Economy development:* production value, job creation, technology investment; *energy utilization*: coal efficiency, water efficiency, electric energy efficiency; *refuse recycle*: waste water recycle, solid waste recycle; *pollutant emissions*: SO_2 emissions, NO_x emissions, soot emissions.	For performance evaluation; in eco-industrial thermal power plants in China; with fuzzy logic, Shannon theory, *GRA* and *VIKOR*.
Process sector Deng et al., 2000	Profitability, productivity, market position and debt ratio.	For company performance; in 7 companies of Chinese textile industry; with *TOPSIS*.
Akyuz and Kuruuzum, 2010	Acceptable product rate, paint defect rate and chemical defect rate.	For measuring and improving manufacturing performance; in mirror manufacturing companies; with coefficient analysis and multiple regression analysis.
Nyaoga et al., 2016	Situations experienced, physical constraints situations, policy constraint situations, paradigm constraints situations, market constraints situations, factors motivating management of operational constraints, value chain strategies, benefit of value added tea production management and responsiveness.	For evaluating value chain performance; in the tea processing companies in Kenya; with *GRA* and *TOPSIS*.
Chmelíková, 2014	*Financial perspective; internal process*: quality and cost; *customer perspective:* customer loyalty; *learning and growth*: skilled employees and employee productivity.	For company performance; in Chile breweries; with *BSC*, correlation analysis.
Rezaie et al., 2014	*Liquidity ratios:* current ratio; quick ratio; cash ratio; *financial leverage ratios:* debt ratio, shareholder's equity to total assets ratio, fixed assets to shareholder's equity and fixed assets to long term debt; p*rofitability ratios:* net profit margin and return on equity; *growth ratios*: sales growth, operating profit growth, shareholders' equity growth and assets growth.	For evaluating company performance by financial ratios; in 27 listed Iranian cement companies; with fuzzy logic, *AHP* and *VIKOR*.
Abbasi and Kaviani, 2016	*Input*: quality, cost, dependability, flexibility and speed; *output*: *ROA*, *ROI* and market share.	For evaluating operating effectiveness; in cement manufacturers of Iran; with fuzzy logic, *DEA* and GRA.
Ertuğrul and Karakaşoğlu, 2009	*Liquidity ratios*: current ratio; quick ratio; cash ratio; *financial leverage ratios*: debt ratio, shareholder's equity to total assets ratio, fixed assets to shareholder's equity and fixed assets to long term debt ratio; *activity ratios*: account receivable turnover, inventory turnover ratio, current assets turnover ratio, total asset turnover ratio, accounts payable turnover ratio; *profitability ratios*: net profit margin ratio, return on equity ratio; *growth ratios*: sales growth, operating profit growth, shareholders' equity growth, assets growth.	For evaluating financial performance; in 15 listed Turkish cement manufacturers; with fuzzy logic, *AHP* and *TOPSIS*.
Moghimi and Anvari, 2014	*Liquidity ratios*: current ratio; quick ratio; *financial leverage ratios*: debt ratio, shareholder's equity to total assets ratio, fixed assets to shareholder's equity ratio and fixed assets to long term debt ratio; *activity ratios*: account receivable turnover, inventory	For evaluating financial performance; in 8 Iranian cement companies; with fuzzy logic, *AHP* and *TOPSIS*.

	turnover ratio, current asset turnover ratio, total asset turnover ratio; *profitability ratios*: net profit margin ratio, return on equity ratio. *growth ratios*: sales growth, operating profit growth, shareholders' equity growth, assets growth.	
Parthiban and Goh, 2011	*Process efficiency*: operating cost per employee, cost of goods sold, product development time, rejection ratio, actual production against planned production, age of plant and equipment and capacity utilization; *product and process innovation*: R&D expenditure, number of new products in the last 3 years and percent of products protected by patents; *product quality and customer satisfaction*: customer surveys and warranty claims, customer complaints, service responsiveness and percent of returned orders.	For manufacturing performance; in 2 Indian valve manufacturing companies; with *AHP* and quality function deployment.
Tavana et al., 2015	*Financial*: EPS, P/E ratio, sales growth, debt ratio, rank of liquidity, cost of goods sold; *customer:* market share, volume of exports, customer satisfaction, customer loyalty and increasing of customer; *learning and growth:* number of registered drugs, advertising and marketing, employee satisfaction, employee training, increasing of employee and number of updating formula; *internal process:* number of products, management performance, new technologies, percent of waste and number of acquired certificates.	For evaluating company performance; in 21 listed pharmaceutical companies; with *BSC*, *DEMATEL*, fuzzy logic, *ANP*,*DEA* and Shannon theory.
Electronics Chiu et al., 2014	*Input:* fixed assets, number of employees and R&D stock. *Output:* revenue and patent number of stock.	For production efficiency; in cross-strait solar photovoltaic manufacturers; with *DEA*, Spearman's correlation analysis.
Hsu, 2015	*DEA-Input*: number of employees, fixed assets, total asset; total debt, operating expenses, selling expenses, administrative expenses, *R&D* expenses and inventory. *DEA-Output:* total revenue, net sales, net profit ratio, gross profit margin and operating income. *Profitability*: returns on assets, returns on equity, operating profit margin, net profit margin after tax and earnings per share; s*olvency*: current ratio, quick ratio, debt ratio, long-term capital ratio, cash flow ratio and cash reinvestment ratio; *operating ability*: total assets turnover, accounts receivable turnover, inventory turnover, average daily sales, fixed assets turnover and shareholder equity turnover.	For ranking efficiency of operating performance; in Taiwan's listed semiconductor companies; with *VIKOR*, Shannon theory, *DEA*, improved *GRA* and Spearman's correlation analysis.
Kozmetsky and Yue, 1998	Market share and economic growth, employment and labour productivity, cost efficiency, profit margin, *R&D* expenditure ratio and market value.	For evaluating company performance; in 56 global semiconductor companies; with *DEA* (*CCR*).
Tseng et al., 2009	*Competition performance*: sales growth rate and market share; *financial performance*: earnings profitability, capital structure, market value and cash turnover ratio; *manufacturing capability*: cost efficiency, product yield rate, manufacturing flexibility, productivity and product quality level; *innovation capability*: number of patents, R&D expenditure ratio, ability to obtain critical technology, capability to improve manufacturing processes; *supply chain relationships:* upstream materials and supplies, downstream tactical alliances.	For evaluating company performance; in Taiwan's large-sized thin-film transistor liquid-crystal display panel companies; with fuzzy logic, *AHP* and *TOPSIS*.
Automotive Senvar et al., 2014	Decreasing of inventory waiting time, increasing profit/cost of sale product, increasing of customer continuity, increasing of capacity, increasing of *R&D* investment per employee, increasing of total performance of suppliers.	For evaluating company performance; in Turkish automobile companies; with fuzzy logic, *AHP* and *BSC*.

Bulgurcu, 2013	Current ratio, acid test ratio, total debt ratio, debt equity ratio, current assets turnover, fixed assets turnover, net profit margin, return on equity, working capital turnover and return on assets.	For measuring financial performance; in the Turkish automotive companies; with *TOPSIS* and Shannon theory.
Talebnia, 2012	*Financial perspective, customer satisfaction perspective, internal processes perspective* and *organization's innovation perspective.*	For assessing company performance; in Iranian auto industries. with fuzzy logic, *AHP* and *BSC.*
Amrina and Yusof, 2011	*Environmental performance:* emissions, resource utilization and waste; *economic performance:* quality, cost, delivery and flexibility; *social performance:* employee and supplier.	For evaluating sustainable manufacturing performance; will in Malaysian automotive companies; with pilot study.
Fuzi et al., 2012	Environmental performance and social performance; employee involvement, customer focus, environment, corporate governance, community and society and human right.	For corporate social responsibility performance; in Malaysian automotive industry; with *SEM* and *FA.*
Amrina and Yusof, 2010	Quality, delivery, cost, time and labor.	For evaluating manufacturing performance; in Malaysian automotive small and medium companies; with *AHP*.
Automotive & Aerospace Beelaerts van Blokland et al., 2010	*Competition performance:* turnover; *financial performance*: share price; *manufacturing capability:* cars/trucks per capita; *supply chain relationships*: turnover per capita; *innovation capability: R&D* expenditures per employee.	For quantifying companies' capabilities in creating value; in 33 automotive *OEM*s and 5 aerospace *OEM*s; with bivariate correlation analysis and multiple regression analysis.
Maaskant, 2011	*Competition performance:* operating revenue growth, operating revenue; *financial performance:* operating income, operating margin, market capitalization; *manufacturing capability:* manufacturing assets utilization, operating income per employee; *innovation capability: R&D* efficiency and *R&D* effort; *supply chain relationships*: operating revenue per employee, inventory turnover and operating revenue per backlog.	For operations performance based on their value creating abilities; in aerospace *OEMs*; with *DEA* and bivariate correlation analysis.
Elferink, 2010	*Competition performance:* sales growth rate, turnover and market share; *financial performance:* share price; *manufacturing capability:* profit per employee, inventory turnover and vehicles per employee; *innovation capability: R&D* efficiency and own *R&D* efforts; *supply chain relationships*: turnover per employee and profit leverage.	For company performance; in 33 automotive *OEM*s and 5 aerospace *OEM*s; with bivariate correlation analysis.
Aerospace Beelaerts van Blokland et al., 2012	Turnover per employee, *R&D* per employee, profit per employee.	For measuring companies' value-leverage capability; with 41 companies in aerospace industry; with correlation analysis.
Others Hourneaux Jr et al., 2017	*Monitoring*: progresses toward goals, monitors results, compares results with expectations and reviews principal measures; *focus of attention*: 6 measures; *strategic decision-making:* 7 measures; *legitimization:* 8 measures.	For evaluating company performance; in São Paulo manufacturers; with descriptive statistics analysis and *FA.*
Yalcin et al., 2012	*Traditional accounting-based financial performance*: return on assets, return on equity, earning per share and price/earnings ratio; *modern value-based financial performance:* economic value added, market value added, cash flow return on investment and cash value added.	For evaluating financial performance; in 7 Turkish manufacturing sectors; with fuzzy logic, *AHP, TOPSIS* and *VIKOR.*
Coskun and Bayyurt, 2008	*Financial*: financial operations and profitability; *process*: operational activities, innovation and resource utilization; *customer*: customer relations, marketing costs, market share and	For company performance; in 500 Turkish manufacturing companies; with *FA,* Canonical

	sales volume; *learning and growth*: work environment, employee relations and employee capabilities.	Correlation Analysis and *BSC*.
Behrouzi and Wong, 2011	*Waste elimination*: quality, cost and time; *JIT*: delivery.	For evaluating lean performance; in a manufacturing company; with fuzzy logic.
Digalwar et al., 2015	Top management commitment, knowledge management, employee training, innovation and technology, employee empowerment, environmental health and safety, supplier management, production planning and control, quality, flexibility, speed, cost, customer involvement, customer satisfaction, customer services and company growth.	For performance measures of world class manufacturing companies; with experts opinion and SEM.
Gomes et al., 2011	Financial, product quality and customer satisfaction, human resource management, process efficiency, social responsibility, competitive environment, quality/independence of management, product and process innovation.	For company performance; in Portuguese manufacturing organizations, with CA and regression analysis.
Susilawati, 2016	Financial perspectives, supplier issues customer issues, process, people and future.	For evaluating lean manufacturers' performance; with fuzzy logic and *AHP*.
Bititci et al., 2013	Growth in profitability, growth in value-added productivity, growth in cash flow, growth in revenue, employee satisfaction and growth in market share.	For company performance; in 37 small and medium manufacturing companies; with *CA* and *FA*.

Note: BSC – the balanced scorecard, DEMATEL - decision making trial and evaluation laboratory, SEM - structural equation modelling, OEM - original equipment manufacturer, CA - cluster analysis, FA – *factor analysis*

Appendix B

Questionnaire of company performance measures.

Here the question is: what is the importance of the different indicators in measuring company performance? Your answer will contribute for weighting the indicators, with techniques of fuzzy logic and analytic network process.

Give the importance level of different parameters from 1 to 9 as Table 1.

Table 1: The importance levels of the different performance indicators

Importance levels	Definition
1	Equal importance
3	Moderate importance of one over another
5	Essential or strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments

Example: To evaluate the importance levels of Competition performance, Financial performance and Manufacturing capability with respect to company performance. For the blue box, it represents: competition performance/ financial performance. In my opinion, I suppose CP is two times important than FP to present the company performance. So I put 2 in it.

	CP	FC	MC
Competition performance (CP)	1	2	1
Financial performance (FP)	**1/2**	1	1/4
Manufacturing capability (MC)	1	4	1

Noted: 1. All the data in the diagonal is fixed as 1; each blank is the importance **ratio of the horizontal parameter to the longitudinal** parameter.

Are you clear with the method? If you are ready, then **please fill out the boxes in the upper right half** (Tables 1-1) according to your own judgment and cognition.

1. Table 1-1: Comparisons of Competition Performance, Financial Performance, Manufacturing Capability, Technology Performance, Supply Chain Relationship and Inventory Performance.

Company performance	CP	FP	MC	TP	SCR	IP
Competition Performance (CP)	1					
Financial Performance (FP)		1				
Manufacturing Capability (MC)			1			
Technology Performance (TP)				1		
Supply Chain Relationship (SCR)					1	
Inventory Performance (IP)						1

Those dimensions probably cannot be independent with each other completely.

Please fill out the boxes in the lower right half (Tables 2-1 to 2-6) according to your own judgment and cognition.

2. Table 2-1: The inner-dependence comparisons with respect to "Competition Performance"

Competition Performance	FP	MC	TC	SCR	IP
Financial Performance	1				
Manufacturing Capability		1			
Technology Performance			1		
Supply Chain Relationship				1	
Inventory Performance					1

3. Table 2-2: The inner-dependence comparisons with respect to "Financial Performance"

Financial Performance	CP	MC	TP	SCR	IP
Competition Performance	1				
Manufacturing Capability		1			
Technology Performance			1		
Supply Chain Relationship				1	
Inventory Performance					1

4. Table 2-3: The inner-dependence comparisons with respect to "Manufacturing Capability"

Manufacturing Capability	CP	FP	TP	SCR	IP
Competition Performance	1				
Financial Performance		1			
Innovation Performance			1		
Supply Chain Relationship				1	
Inventory Performance					1

5. Table 2-4: The inner-dependence comparisons with respect to "Innovation Performance"

Technology Performance	CP	FP	MC	SCR	IP
Competition Performance	1				
Financial Performance		1			
Manufacturing Capability			1		
Supply Chain Relationship				1	
Inventory Performance					1

6. Table 2-5: The inner-dependence comparisons with respect to "Supply Chain Relationship"

Supply Chain Relationship	CP	FP	MC	TP	IP
Competition Performance	1				
Financial Performance		1			
Manufacturing Capability			1		
Technology Performance				1	
Inventory Performance					1

7. Table 2-6: The inner-dependence comparisons with respect to "Environmental Performance"

Inventory Performance	CP	FP	MC	TP	SCR
Competition Performance	1				
Financial Performance		1			
Manufacturing Capability			1		
Technology Performance				1	
Supply Chain Relationship					1

Please fill out the boxes in the lower right half (Tables 3-1 to 3-5) according to your own judgment and cognition.

8. Table 3-1: Comparisons of sub-measures within "Competition Performance"

Competition Performance	Sales Turnover	Market Share
Sales Turnover	1	
Market Share		1

9. Table 3-2: Comparisons of sub-measures within "Financial Performance"

Financial Performance	Profitability	Market Capitalization	Financial Leverage	Cash flow margin
Profitability	1			
Market Capitalization		1		
Financial leverage			1	
Cash flow margin				1

10. Table 3-3: Comparisons of sub-measures within "Manufacturing Capability"

Manufacturing Capability	Productively	Continuity
Productively	1	
Continuity		1

11. Table 3-4: Comparisons of sub-measures within "Technology Performance"

Technology Performance	Conception	R&D Efficiency
Conception	1	
R&D Efficiency		1

12. Table 3-5: Comparisons of sub-measures within "Supply Chain Relationship"

Supply Chain Relationship	Profit Leverage	Inventory Turnover
Profit Leverage	1	
Configuration		1

13. Table 3-5: Comparisons of sub-measures within "Inventory Performance"

Inventory Performance	Inventory Turnover	Inventory Efficiency
Inventory turnover	1	
Inventory efficiency		1

Which of the following best describes your occupation?
□ Marketing and Sales occupations □ Business and Financial Operations occupations
□ Computer and Mathematical occupations □ Management occupations
□ Office and Administrative Support occupations □ Production occupations
□ Transportation and Material Moving occupations □ Life, Environment and Social Science occupations
Other (Please Specify):

Acknowledgment

I would like to thank all those who co-operated in conducting this survey for their input and for willingness to be interviewed. To preserve their anonymity, they will not be named. Without their help, this survey could not have been carried out.

The Next Generation of Facility Management: Nurturing Millennial Leadership

Jake A. Gunnoe, PhD
Leadership Society of Arizona
Mesa, AZ, USA

Jacob S. Kashiwagi, PhD
KSM Inc.
Mesa, AZ, USA

Rick Corea
ON Semiconductor
Phoenix, AZ, USA

Workforce demographics are changing as baby-boomers approach retirement. By 2020, nearly half of the workforce will be younger than 35. This poses a challenge in industries that are dominated by older employees. This paper examines how changing workforce demographics will affect one of these at-risk industries, facility management. The authors propose that to mitigate the negative effects of an employee exodus, the FM industry (and other similar industries), will have to embrace the next generation of leadership. The authors suggest that young employees may not have the same technical training as older employees, but they can still effectively assume leadership roles if they are taught to properly integrate new technology and utilize the expertise of others. This teaching methodology is the "FM of the Future" approach. This research shows the results of implementing the "FM of the Future" approach in an International Facility Management Associate student chapter to create a pipeline of high-performing students to assume FM roles. The results of the effort reveal two key findings: college students can implement this model to effectively manage industry projects which result in significant cost avoidance ($4 million), and second, high school students can use this training to develop leadership skills to help them become less stressed, more stable, and better students. The authors recommend additional case studies with both college students and high school students.

Keywords: Education, Facility management, test results, performance.

Introduction

Over the past several decades, the baby-boomer generation (born around 1940 – 1960) has been the driving force of the economy. To this day, they are still the largest generation in the U.S. population; comprising about 65 million people (see Figure 1). Generation X (1960 - 1980) is next in line to replace the baby-boomers, but the population is about 10% smaller (59 million people). Each year, the millennial generation (1980 – 2000) becomes a larger presence in the workforce as student's graduate college. This age group is about 4% larger (61 million) than Gen X. By 2020, 25% of the labor force will be older than 55 and 46% will be millennials.

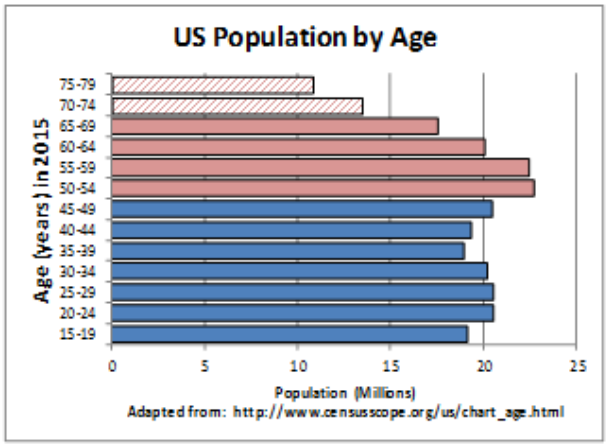


Figure 1: Age distribution of the US population in 2015 (in millions. U.S. Census, 2012).

These workforce trends are having a significant impact on various industries, particularly in construction, and facility management. The problem is twofold:

1. Fewer young professionals are entering the construction and facility management industries.
2. Companies across the U.S. state that millennials lack the necessary training to enter the workforce.

Workforce Shortage

Seventy-nine percent (79%) of general contracting firms report a shortage of craft laborers and 52% report a shortage of full-time salaried professionals (AGC, 2015). The International Facility Management Association (IFMA) has identified that a large group of Facility Managers (FM) in upper level management/leadership roles are in the twilight of their career and there is a perceived shortage of FMs who can fill their leadership/management positions once they retire (Hightower, et al. 2013. Sullivan, et al. 2010). The 2017 joint industry report from IFMA and RICS states:

> *"A shortage of skilled Facility Management talent is the most significant challenge identified by both the survey respondents and the executives who were interviewed directly. Facility Management is not attracting enough new talent to replace its retiring professionals,"* (RICS, 2017).

The report goes on to mention that less than 15% of FMs are under 40. This has inspired the motivation for Global Workforce Initiative: "to fill the growing FM workforce talent gap as more than half of today's practitioners are expected to retire in the next 5-15 years," (Career builder…, 2015).

The average pre-millennial worker in the United States remains at their job for 4.4 years. Ninety-one percent (91%) of millennials (born between 1986 and - 2000) have reduced that number by half and are projected to have 15-20 jobs in their lifetime (Meister, 2012). The number of graduates with construction and FM related degrees continues to decrease by 5 – 6% each year

(Gallup, 2013). Millennials are not interested in working the same way, or in the same career fields, as their parents.

Millennial Preparedness

A recent study suggests that 89% companies across various industries think that recent graduates are ill-suited to enter the workforce (Gallup, 2013). Less than 50% of recent graduates possess the 17 most desirable skillsets as identified by most employers (Jaschik, 2015). McKinsey and Company identified that 61% of new graduates are unhappy with their careers, and 57% of employers agree that they cannot find enough skilled entry-level workers (McKinsey & Co., 2013). Another study assessed survey results of 2,322 students over a four-year period. Test results identified that 45% of the students made no significant improvement in their critical thinking, reasoning or writing skills during the first two years of college (2013).

Understanding the Problem

There is discord among researchers regarding the cause of these workforce trends. Authors such as Simon Sinek feel that the issue are a result of bad parenting, technology addiction, and workplace culture (McKinsey & Co., 2013). Many agree with Sinek in their belief that millennials are lazy, entitled, narcissistic, and socially inept. On the other hand, other researchers claim the mindset and habits of millennials are very similar to previous generations when they were in their twenties (2017, April 17). There is no clear consensus on the issue. These studies enable companies to claim that they cannot work with millennials because they are entitled or lazy, but according to the research, this may or may not be true. The best answer is for companies to learn how to adapt to millennials instead of trying to change them.

The problem in the facility management (FM) industry is that most millennials are not interested in the career field. The traditional FM rose to their position through technical ranks (plumbing, electrical, mechanical, custodial, etc.). More millennials are going to college than ever before, so their entrance into the FM industry will need to be drastically different than the traditional route (Rimer, 2011). To engage the millennial workforce, the nature of FM will need to evolve.

The Next Generation of Facility Management

The future is in technology; namely, automation and robotics. As technology advances, more systems and job functions will be replaced by artificial intelligence, information systems, and computers. Many technical job functions will be replaced by machines, and the job functions that cannot be automated will require highly-specialized experts.

International Facility Management Associate (IFMA) Fellow, Dr. Dean Kashiwagi has recently coined two new terms “FM Professional of the Future” and “FM Associate of the Future” (Kashiwagi, 2015). Kashiwagi believes that technology will drastically change the FM industry. FM Professionals will shift their focus away from technical skills and instead focus on leadership. FM Associates will become highly specialized technical experts capable of

accomplishing any tasks that cannot be automated. The FM Professional will be company leaders and a critical part of any C-suite. They will know how to utilize the expertise of the FM Associates as well as integrate with new technology. The FM Professional will take a leading role in organizational management. He or she will not only maintain a building but will also be the driving force behind maintaining and advancing a company's physical assets.

These industry trends perfectly coincide with millennial workforce trends. The young workforce is the first ever to have grown up alongside computers and information technology. Many young employees are highly computer literate and, as a result, are more comfortable incorporating automation in their daily lives. Furthermore, millennials are being hired into leadership positions at younger ages more than any other generation (Bernsin, 2013). Millennials are more interconnected and able to use technology to leverage a wide network of individuals. There is a natural divide in millennials; while all are comfortable using technology, many are preferring leadership positions while the rest are teaching themselves to be technical geniuses at young ages. This makes millennials a natural fit for the FM Professional and Associate dichotomy.

Based on their natural skillsets, millennials might be misaligned. The modern education system is designed to train students to memorize and repeat information, but companies claim that students do not know the right information relevant to job functions. Technical knowledge is not one of the top 10 most important skillets for recent graduates entering the workforce. Employers feel that interpersonal skills are more valuable because new hires can be trained in technical skills (Burnsed, 2011). Millennials have grown up in a world where they have immediate access to information, so memorizing information is becoming less relevant. Education should not attempt to teach everyone to be technical experts. Instead, the primary role of education should be to help students become industry leaders, capable of aligning expertise. The technical experts will naturally reveal themselves as they are given more opportunities to leave traditional education in favor for trade schools or vocational training.

The authors propose that solution to improving millennial performance is twofold:

1. Millennials need more industry-related leadership opportunities early on in their education.
2. Companies will benefit by leveraging millennials' technical prowess instead of expecting them to possess the same skillsets as traditional FMs.

Case Study – A Student Pipeline

There is a gap between what millennials know today and what companies expect them to know. College graduates do not possess the right skillsets to begin working as FMs immediately. The younger workforce is not drawn to the FM profession because the industry does not leverage their strengths and interests. The best way to mitigate these issues is to create a pipeline that introduces millennials to the industry and allows them to work with professionals early on. This pipeline should expose students to real-world challenges faced by FMs and help them learn valuable leadership skills instead of only technical skills. Leadership driven students will receive real-world experience, and technically-minded students will find guidance early on to begin vocational training.

The concept behind this pipeline is now being tested at the IFMA Greater Phoenix Chapter in Arizona through their Student Chapter at Arizona State University (ASU). Over the past five years, the ASU Student Chapter has been piloting a method that connects college students with industry leaders and high school students.

The remaining contents of this report details a case study examining the ASU Student Chapter's efforts to create an FM pipeline. The case study methodology is as follows:

1. Identify leadership-oriented college students and elect them to run the IFMA student chapter.
2. Students partner with IFMA professionals for mentorship.
3. Students earn degrees by publishing industry-based research.
4. Students apply knowledge on small-scale FM projects with local chapter members.
5. Students mentor high school students exposing them to the FM Professional/Associate pipeline.

Case Study Results

In 2004, IFMA and ASU formed a close partnership to help students earn FM-related degrees and certifications. As part of this effort, IFMA Fellow Rick Corea, helped form the IFMA Greater Phoenix Student Chapter. Over the years, the student chapter has worked to create different mentorship opportunities for students to find internships and network with FM professionals. Since its creation, the student chapter has continued to grow every year, and has won Student Chapter of the Year in 2014 and now in 2017.

The student chapter focuses three continuous efforts:

1. Help facilitate effective FM education.
2. Collaborate and network with industry leaders.
3. Create a sustainable pipeline of new FM students.

These efforts have resulted in the creation of an FM pipeline that unites college students, industry professionals, and high school students. Each of these pipeline components will be examined in this section of the report.

College Students – FM Education

Since 2004, ASU has offered a variety of FM-related classes and provided routes for students to receive their SFP and FMP certification. Over the past 24 years, three different professors at ASU have lead over 1,900 industry-based research projects valued at $6.8 billion ($17.6 million in research funding). These research efforts have created numerous opportunities for students to collaborate on FM-related partnerships. As a result, over 300 student-supported papers have been published. Together, the FM classes and research efforts have helped six students earn their doctorates, and eight students earn their master's degrees since 2010 (two graduates per year). Each of these graduates have been able to find prestigious jobs in both academia and the industry. Several have been hired into jobs that are typically filled by FMs with many more years of industry experience, but nevertheless, each employer highly praised these graduates' abilities.

Industry Professionals – Project Collaborations
In 2015, the ASU Student Chapter leaders devised a plan to engage students with real-world FM challenges. The chapter began to reach out to FM professionals and local business leaders to identify small-scale projects that could be assigned to student groups. These projects ranged in disciplines faced by FMs (construction, data analysis, financial projections, and supply chain management). Students would form groups of three or four, and throughout one semester, they would meet with FMs, analyze the problem, propose a solution, execute the project, and present their results. Over the course of two years the program has accomplished the following:

- Partnered with 10 companies
- Completed 25 out of 27 industry projects successfully.
- Average client satisfaction rating is 97%.
- Cost realization of $100,000 and cost avoidance of over $4 million.

High School Outreach – Sustaining the Pipeline
In 2013, several student chapter members created a high school outreach program. With the help of Dr. Dean Kashiwagi, the Student Chapter created a high school leadership development curriculum based off portions of the FM curriculum at ASU. During the summer of the 2013, student chapter members taught a week-long course to 13 high school students at ASU. After facilitating summer programs for three years, student chapter members founded a non-profit organization, Leadership Society of Arizona (LSA). LSA enabled chapter members and IFMA professionals to partner directly with high schools during the year and fuel programs with grant funding. Over the past four years, Student Chapter members have continually worked through LSA to partner with educators and professionals to develop 23 programs for over 470 high school students. The results are as follows:

Teacher Feedback

- Overall program rating: 100%
- 66% of teachers noted student improvements.
- 77% of students showed improvement in class.
- Student overall class performance improved by 9%.

Student Feedback

- Student satisfaction rating: 98%
- 94% of students feel more accountable.
- 75% of students feel less stressed.
- 64% of students feel more confident.
- 55% of students feel more prepared to succeed in school.

The greatest largest impact for many of these students is seen in their personal lives. Student chapter members sought to provide leadership education to help improve career and college readiness, but to their surprise, these programs changed the lives of many students, for example:

- Student 1 used course concepts to help prevent a friend's suicide.
- The parents of Student 2 claimed that the course did more for their child's confidence than the previous two years of counseling.
- Student 3 overcame depression caused by bullying and learned to resolve her personal conflicts.
- The parent of Student 4 realized that his son did not to follow in his footsteps to be an engineer and was able to improve their relationship.

Conclusion

The FM industry is hard-pressed to engage the millennial workforce. Recent graduates are moving towards other industries in search of leadership positions instead of technically focused career paths (such as traditional roles filled by FMs). Simultaneously, the FM industry is poised to change drastically as technology becomes more integrated with daily job functions. The role of future FMs will likely need to change to remain a vital part of any company. Automation and technology will replace many job functions; the remaining responsibilities will require highly-specialized experts. The industry will be divided into FM Professionals (company leaders) and FM Associates (technical experts). FM Professionals will need to integrate with technology, hire FM Associates, and efficiently unite the two. Since FM Professionals will not be able to master all these technical functions, they will need to assume a leadership role. Since most millennials are migrating towards leadership positions, FM will naturally become more attractive to them as they begin to see its crucial value in a company. FM Associate positions will begin to attract more technically-minded millennials because FM Professionals will value them for the expertise instead of over-managing them.

The IFMA Greater Phoenix Student Chapter conducted a multi-year FM pipeline case study to investigate whether millennials can become effective FMs by learning more leadership-oriented skills opposed to technically-oriented skills. The student chapter created pathways for their members to conduct their own FM-based research, manage real-world micro-projects, and teach leadership skills to high school students. This case study has resulted in 14 FM graduate degrees, over 300 student publications, 25 student lead projects, $100K in project cost realization, $4M in project cost avoidance, 23 high school programs, and a lasting impact on over 470 high school students.

The student chapter FM pipeline has shown to be a highly successful initiative capable of producing effective millennial leaders. The authors propose that this model can be recreated with other IFMA chapters to better engage college and high school students. This pipeline will train more effective leaders and will quickly identify technical experts to guide them towards vocational training. The authors believe that as the FM career path becomes more leadership oriented and willing to embrace new technology, it will attract more young employees. As these young employees receive leadership-focused training and are given real-world project responsibilities, they will become highly successful future FMs.

References

AGC. (2015). 2015 Workforce Survey Results – National Survey Results. The Associated General Contractors of America. (September 9, 2015) Retrieved from: https://www.agc.org/news/2015/09/09/nationwide-survey-finds-86-percent-contractors-have-difficulty-filling-key-craft-and

Bernsin (2013). “Millennials Wil Soon Rule the World. How Will They Lead?” Forbes. Web (September 2013). https://www.forbes.com/sites/joshbersin/2013/09/12/millenialswillsoonruletheworldbuthowwilltheylead/print/

Burnsed, B. (2011). Specialized Majors: High Risk, High Reward. U.S.News & WORLDS REPORT. (April 2016).

CareerBuilder and EMSI Release List of College Degrees Experiencing the Greatest Growth and Declines Post Recession (2015, September 3).

D. (n.d.). Transcript of Simon Sinek Millennials in the Workplace Interview. Retrieved from https://www.ochen.com/transcript-of-simon-sineks-millennials-in-the-workplace-interview

Gallup, 2013. What America Needs to Know About Higher Education Redesign. February 2014. http://www.gallup.com/services/176759/america-needs-know-higher-education-redesign.aspx

Hightower Jr, R., & Highsmith, J. (2013). Investigating the Facility Management professional shortage. International Journal of Facility Management, 4(3).

IFMA Foundation Internship Development Guidelines. (n.d.). Retrieved from https://foundation.ifma.org/

Jaschik, S. (2015). Well-Prepared in Their Own Eyes. Inside Higher ED. Web (April 2016). Retrieved from https://www.insidehighered.com/news/2015/01/20/study-finds-big-gaps-between-student-and-employer-perceptions

Kashiwagi, Dean, et al. "Research Program to Sustain the FM Professional." Journal for the Advancement of Performance Information & Value 7.1 (2015).

Kovacs, 2016. The State of Undergraduate Education. Inside Higher Ee. September 2016. https://www.insidehighered.com/news/2016/09/22/more-people-enroll-college-even-rising-price-tag-report-finds

McKinsey & Company. (2013). McKinsey Global Institute. W.P. Carey Business Career Center. http://www.forbes.com/sites/joshbersin/2012/12/10/growing-gap-between-what-business-needs-and-what-education-provides/.

RICS, 2017. Raising the Bar Executive Summary. March 2017. http://www.rics.org/Documents/Raising_the_Bar_3_Exec_Summary_130317_IC.PDF

Rimer, S. (2011). Study: Many college students not learning to think critically. The Hechinger Report. McClatchyDC. Web (March 2016). Retrieved from http://www.mcclatchydc.com/news/nation-world/national/article24608056.html.

Sullivan, K., Georgoulis, S. W., & Lines, B. (2010). Empirical study of the current United States facilities management profession. Journal of Facilities Management, 8(2), 91-103.

U.S. Census Bureau. (2012). Washington, D.C.: Government Printing Office. U.S. Census Bureau. (2012). Electronic ownership by household. Retrieved from http://www.census.gov/data/2012

What Simon Sinek Got Wrong about Millennials in the Workplace. (2017, April 17). Retrieved from https://www.thindifference.com/2017/01/simon-sinek-got-wrong-millennials-workplace/

Volume 10, Issue 1

Table of Contents

Table of Contents

CIB W117 .org

ISSN 0000-0191 00191
9 770000 019418

ISSN
216-0464 (Online)
2169-0472 (CD-ROM)