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Letter from the Editor **November 2020**

Visionaries:

We have been denied twice this year by the gatekeepers who rank journals. The reasons were subjective in that we do not have sufficient involvement and support of the "traditional" research community. Due to this result [which will be published in more detail in our next journal], the effort to pursue journal ranking will be immediately ended. Instead, we will continue to do the following:

- Document industry testing of the Best Value Approach's (BVA) procurement, risk management, project management, automation of supply chain activities and structures and the transformation of the roles within the supply chain.
- Document the resistance to change by the traditional structure of professionals who are having their tasks minimized by the information technology and automation. This includes the resistance to our journal by professionals who have never done successful research.
- Document the Information Measurement Theory (IMT) and the Best Value Approach (BVA) that utilizes simplicity and expertise to increase the value of services while decreasing the cost and number of [professional] personnel required. This will include the documentation of the obvious relationship between IMT and BVA and information systems, robotics, automation, and artificial intelligence (AI), which are at the foundation of value generation.
- Documenting the current environment of the delivery of services will become more significant than the quoting of industry professionals, who are a part of the traditional structure that are resisting change to stay relevant. The value of journal papers published in rated journals, which quote professionals from the traditional approaches, is going in the wrong direction [complexity, more studies, more research and more conclusions requiring more research] and is proliferating papers which have no value.

It is obvious that the world is moving toward automation and artificial intelligence to increase production, value and to reduce cost. This is the future of project management and risk management. Both will be information based. In both applications, the humanistic processing will be minimized and replaced by the brains of automation [artificial intelligence]. The mechanisms will be simplicity and minimized human interactions.

We will continue to use Research Gate for metrics on the impact of the journal papers. We will also continue to get the published papers reviewed and "on the street" as soon as possible to allow industry and academic researchers to utilize the research results. The reads of journal papers have increased 700% in three years. We encourage all researchers in the specialty areas of performance information, facility management, project management, risk management and supply chain management to get their papers into the industry as soon as possible.

We have now successfully moved the Performance Based Studies Research Group (PBSRG) research from the Arizona State University (ASU) Ira A Fulton Schools of Engineering to the SKEMA Business School, Project Management Doctor of Business Administration (dBA) Program. This was done for the following reasons:

1. The delivery of services is not an engineering issue.
2. It is a project management, risk management, supply chain issue.

We are grateful for the early development of the BVA at ASU, but the future of the BVA research is in the business/project management environment. The research at SKEMA involves seven different research efforts. We will continue to recognize the contribution of ASU by licensing the BVA technology from the ASU Skysong Innovation group [responsible for patents and licenses at ASU].

The W117 research agenda for the next five years includes:

1. Changing the structure of W117. Research will be recursive as the actions of all the participants in the W117 structure will be actively participating in the research.
2. Forming an international board of experts in the Best Value Approach (BVA). This board will run tests, document the tests with peer reviewed papers, and become reviewers for other BVA papers.
3. Forming PBSRG education satellite sites that are facilitated by BVA International Board members to proliferate the BVA.
4. Implementing the BVA into both private and public organizations in the United States to replace management, direction and control in the delivery of services by identifying and utilizing expertise.
5. A research effort to change the project management model from the management, direction and control approach to the utilization of expertise and transparency. This effort is integrating the BVA test projects and the research effort at the SKEMA Project Management School to define the Project Management Model and the Risk Management Model of the Future.
6. Use a new component of W117, Leadership Society of Arizona (LSA), to test and implement IMT information concepts to prepare young students to operate in the age of automation by minimizing thinking, data collection and decision making. This education overcomes the paradox of how to understand reality with minimal information. These programs produce Information Workers (IW) who use the language of dominant metrics to understand the present and future conditions of reality.

From the previous journal, the design of an Information Based Continuous Improvement (IBCI) system which uses accurate and timely performance information to optimize the Kingdom of Saudi Arabia classification system and improve construction quality has been discontinued. The Saudi government officials and Saudi consultant on the project could not grasp the concepts of an information-based system that could minimize the myriads of management layers of internal managers and external consultants. Instead, millions of dollars were spent to build a project management system that would not be transparent or have accurate information.

I encourage journal readers to dream of innovation. This year (2020) will produce results which will dwarf the results previously discovered in the use of performance information.

Best wishes to everyone!

Dr. Dean

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Development of the Use of Performance Information

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This paper documents the history of the development of performance information [1982-2020], for the delivery of services. It identifies traditional industries as client controlled. In the past, clients utilized a structure of technical professionals who had education, certifications, and experience. Professionals set both policy and structure for their professionalism. The traditional industry does not differentiate between the values of vendors, professionals and stakeholders. This paper identifies that professionals are resistant to using performance information which differentiates. The initial proposal to successfully implement information management was to use automation. However, the industry resisted the automation and the research identified that simplicity and transparency was the only solution. This paper identifies that the Performance Based Studies Research Group's (PBSRG) success in performance information development was due to a unique design and methodology to research performance information as a disruptive technology. A new methodology called the Information Measurement Theory (IMT) was designed to redefine risk, expertise and information. The major source of validation of the new concepts was joint academic and industry research tests. Three major research tests confirmed that the client creates over 90% of all risk. PBSRG worked with a manufacturing company to design a high-performance roofing program which ended after 16 years due to it being based on client centric concepts. An expert contractor took the lessons learned and maximized the use of performance information with a vendor centric approach.

Keywords: Expert, Expertise, Project Management, Project Performance, Best Value Approach, Procurement, Risk Management, Information Management, Performance Information, Automation.

Introduction Traditional Construction Industry is "Client Centric"

The construction industry has had performance issues for the past 30 years; construction projects were not finishing on time and on budget causing customer dissatisfaction [Berstein 2009; British Property Federation 1997; Cahill & Puybaraud 1994; CFMA 2006; Chan & Chan 2004; CII, 2015; Davis & Sebastian 2009a, 2009b; Doree 2004; Egan, 1998; Egbu, 2008; Georgy Luh-Maan, Lei & Zhang, 2005; Glancy 2008; Horman & Kenley 2005; Ibrahim, Roy, Ahmed & Imtiaz, 2010; IHS Markit, 2013; Imtiaz & Ibrahim 2005; Kashiwagi, & D. Kashiwagi, 2016; Langlinais 2011; Latham, 1994; Diekmann, Songer & Brown, 1999; Lepatner, 2007; Murphy 2012; PBSRG, 2020; Post, 2000; Rijt 2009; Rivera, 2014; Rivera, Le, Kashiwagi & Kashiwagi, 2016; Rivera 2017; Rwelaimila, Talukhaba & Ngowi 2000; Simonson 2006; Tucker 2003; Wang 2009; Wearden 2008]. The traditional construction industry is an "owner centric" industry [Alzara, 2016; Kashiwagi, 2020; PBSRG, 2020; Rivera, 2017]. The core of the client centric industry is a structure of technical professionals who manage, direct and control the supply chain. They utilize design drawings and specifications [directions to the contractors] to identify the clients' requirements. The construction industry is a specification driven industry (Alofi, 2017; Almutairi, 2017; Kashiwagi, 1995; Kashiwagi, Halmrast & Tisthammer, 1996; Gransberg, 2008; Hale, Shrestha, Gibson & Migliaccio, 2009; Konchar & Sanvido, 1998; Lam, A. Chan & D. Chan, 2004; Ling, Chan, Chong, & Ee, 2004; Murphy, 2012; Williams, Young, Tzeyu & Murat, 2003).

Manufacturers of construction products assist the professionals in the construction industry by identifying performance criteria for all products being utilized in construction. The professionals identify the methodology to measure all material criteria [American Society of Testing Materials (ASTM) and other technical organizations]. Once the criteria and (ASTM) tests are agreed upon, each manufacturer tests their own material according to the ASTM test procedures (Blau & Budinski, 1999). The industry then reconvenes with professionals representing industry stakeholders to set the values of the material's performance criteria [example shown in Table 1] [Kashiwagi, 2014a, p. 14.7]. This method of setting material requirements in a project has the following flaws:

1. Requires professionals to make decisions to create the test methodology and the acceptable performance level. Decision making is used because the requirement cannot be easily observed or proven.
2. The final ASTM material specification requirement is a combination of the lowest material criteria values of material provided by participating manufacturers, which cannot ensure "in-field" performance. The relationship between performance criteria set in this manner and "in-field" performance is unknown.
3. The material specification that the client's designers utilize is a result of a combination of the lowest criteria metrics from all the competing manufacturers' material. The specification requirement does not usually represent an actual material [Material B and C in Figure 1 have the lowest criteria metrics].
4. There is no proof that a material that meets the ASTM minimum requirement will perform. This is based on professional's acceptance of the ASTM structure.
5. Professionals do not usually use "in-field" testing to verify material criteria performance.
6. Each manufacturer after seeing the minimum material criteria performance will now attempt to lower their material's performance capability to lower the cost of their material.
7. The professionals using the specification assume that all products have the same performance and meet the industry set minimum requirements.
8. If an industry disaster occurs, the professionals may reconvene and change the ASTM standards and requirements for the materials being investigated.

The fallacy of this approach was demonstrated in the 1980s when an unreinforced polyvinyl chloride (PVC) single ply roofing system prematurely and catastrophically failed by shattering in cold winter conditions (Koontz, 1997; Paroli, Smith & Whelan, 1996). The shattering of the unreinforced PVC system was caused by the migration of plasticizer, resulting in shrinking and brittleness and eventual shattering in cold temperatures. This resulted in the National Roofing Contractors Association (NRCA), the governing industry group in the roofing industry to issue a bulletin, warning clients of the danger to their facilities caused by the shattering of the PVC roof system [NRCA & SPRI, 1990]. The failures also led to the modifying of ASTM standards. The bulletin warned facility owners of the potential catastrophic failure of their roofing system and recommended that owners replace the roofing system as soon as possible. This event shows the shortcomings of the specification system which utilizes ASTM requirements for material specifications. The minimum specification has no relation to actual “in-field” performance. Some ASTM tests attempt to simulate aging and exposure to the sun and professionals extrapolate results to an in-field performance period. However, there is no proven relationship between these simulated tests and in-field performance [Kashiwagi, 1996]. The failed unreinforced PVC roofing system met all the technical ASTM performance requirements for the material product. The same issues were discovered in the testing of the hail resistance of Sprayed Polyurethane Foam roof systems done by Performance Based Research Group (PBSRG) [Kashiwagi, 1996].

Table 1: Example of a Matrix of Manufacturer Performance (Kashiwagi 2014a)

PHYSICAL PROPERTY	TEST METHOD	MANUFACTURER'S DATA						PROPOSED REQUIREMENT
		A	B	C	D	E	F	
Initial Elongation % (break)	D412	150%	100-200%	200%	100-150%	140-250%	140-160%	100% Min.
Initial Tensile Strength (max stress)	D412	400	150-600	450	300-400	400-625	500-600	150 psi Min.
Final Elongation % Weathering	D412	n/a	100% min	200%	125%	N/a	140-160%	100% Min.
Permeance	E96, B	3.7	n/a	3.5	2.9	N/a	2.6-3.0	2.5 U.S. perms Min
Weathering (5000 hours)	G53	No cracking	No cracking	No cracking	No cracking	N/a	No cracking	No cracking
Adhesion	C794	2 pli	6-10 pli	3 pli	n/a	N/a	n/a	2 pli min.
Tear Resistance	D624	20-30 lb/in	n/a	30 lb/in	n/a	33-53 lb/in	n/a	20 lb/in
Low Temperature Flexibility	D522	n/a	n/a	Passes	Passes	N/a	Passes	Passes
Viscosity	D2196	30,000-50,000	8,000-25,000	115-130 KU	< 60,000	Varies	35,000-40,000	35,000-50,000cps
Volume Solids	D2697	62%	80%	57-66%	62%	66%	62%	57-80%
Weight Solids	D1644	0.77	0.66	70-77%	0.75	0.74	0.71	As listed by Mfg.

Owner Controlled Industry Requires Technical Professionals

The traditional owner centric approach requires professionals [architects, engineers, quantity surveyors, purchasing agents and project managers]. All professionals require a combination of minimum college education, certification through testing and in-field industry experience. Similar to other complex industries, the construction industry depends on the education, experience and decision making of their professionals to mitigate risk.

Professionals identify requirements then design, manage and inspect the contractors' work to mitigate project risk. Contractor failure is covered by vendor insurance and bonding. Manufacturers who manufacturer material that does not meet the proper ASTM standards are financially liable for the nonperformance of their products. Professionals are not liable for nonperformance if they utilized and met industry processes which have been setup by other experienced professionals. The minimum specification approach, which motivates contractors to lower cost, moves the responsibility of performance from the contractor and manufacturer to the client's professional representative, who then attempts to mitigate risk through their decision making, directions and control. Many professionals utilize their decision making as their act of risk mitigation. However, Information Measurement Theory (IMT) [Kashiwagi, 2020] identifies that decision making is only required when individuals do not understand what is going to transpire. If a professional knows what is going to transpire, there is no decision making required and there is no risk. Therefore, the professional's decision making, and risk are inseparable characteristics.

Industry Structure (IS), Professionals and Performance Information

The Industry Structure (IS) was created to explain the source of poor performance [schedule, budget and customer satisfaction] of the construction industry, see Figure 1 (Kashiwagi, 2020). Quadrant I is the traditional owner centric environment. It requires professionals to identify the construction requirement using their technical expertise, then to create a project design document that contractors can follow. Contractors compete on price to be selected by the client. The competition is used to ensure that the owner gets the lowest possible price [price-based sector in Figure 1]. This environment assumes the following:

1. All vendors have the same ability to understand and then to deliver the construction requirement. If the owner's professionals identify that a contractor is not capable, the traditional structure allows the professionals to prequalify contractors who could meet the minimum project requirements. Then it is assumed that the prequalified contractors are "all the same".
2. In the United States, the contractors hire professionals who use cost estimating tools to predict construction requirements. It is critical that both the designers and contractor's professionals do not miss the costing of any required construction requirement. Automated tools such as the Building Information Modeling (BIM) [3D drawings] minimize errors in the supply chain.
3. In every country besides the United States, a quantity surveyor professional [who is certified by the Royal Institute of Quantity Surveyors, (RICS)] is utilized to identify every material quantity in the project in the form of the Bill of Quantities (BOQ). The project is then awarded to the lowest priced contractor.
4. The professionals have accurately identified the optimal construction solution.
5. The owner's professionals can identify and mitigate risk through inspection and testing.

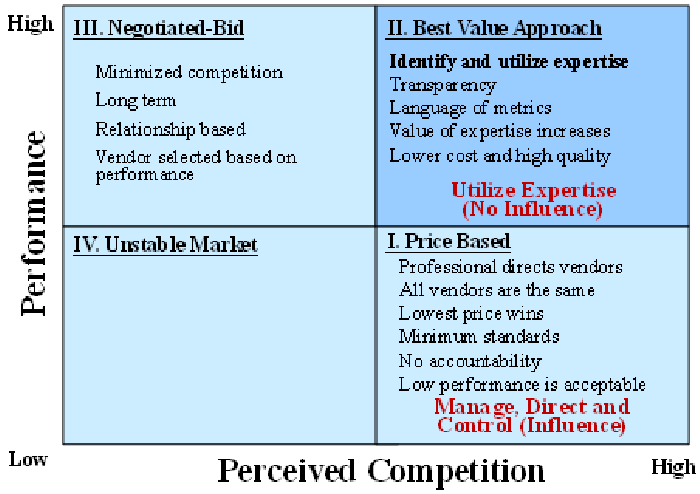

Figure 1: Industry Structure (IS) (Kashiwagi, 2020)

Quadrant I requires the owner to utilize professionals to identify and mitigate risk. The owner's professionals are required to:

1. Identify the construction requirement.
2. Identify the lowest priced contractor. This assumes that all contractors have the same capability to deliver the construction. By observation of the industry nonperformance, [not on time, not on budget, and customer dissatisfaction] this assumption is not accurate. Deductively, when actions are based on concepts that are not accurate, the risk and cost is increased.
3. Manage, direct, and control the contractor to mitigate the risk of not finishing on time, on budget and meeting quality expectations and customer satisfaction. The vendors are attempting to maximize their profit, which motivates them to lower the cost.

As identified by the industry structure (IS) figure, competition is high and performance is low [Kashiwagi, 2020]. The structure of the price-based sector is inefficient and results in lower performance. The impact of the high competition in Quadrant I is that competitors drive the price down. Quality and competition can only both be high, when the level of expertise is high. Quadrant II is an environment where the client identifies the expert contractor based on price and high performance, then utilizes the expertise of the contractor to lower the price. The problem with this concept for the traditional professionals, is that the construction industry and clients do not utilize performance information [on time, on budget and customer satisfaction and previous performance] to select contractors and do not utilize the contractor's expertise [instead they manage, direct and control (MDC) the contractor]. The industry is utilizing professionals' experience, decision making, management and control to minimize risk [nonperformance]. Using performance information to identify and utilize expertise is an extremely different paradigm. The industry does not have experience with using performance information [what it is, how to collect the information, agreement between the clients and the contractors].

The paradigm shift would require the client to accomplish the following:

1. Change the industry supply chain from a client centric approach to a vendor or contractor centric environment.
2. Question the assumption that all contractors "are the same".
3. Question the assumption that the client's professional representative could deliver construction better than an expert contractor.
4. Question if the professionals have the capability to identify the difference among contractors, concepts and options.
5. Transfer the accountability and responsibility for project performance from the owner's technical representative to the expert contractor.
6. Change the role of the owner's professionals to identify, collect and utilize performance information.
7. Change the role of the owner's professionals to quality assurance [non-technical] instead of quality control [technical].
8. Professionals roles would become technical in their specific technical area. With automation and information systems being utilized, professionals will have an ever-shrinking role.

Based on the poor performance of the traditional construction approach [owner centric environment], the Industry Structure (IS) proposes that the contractor and not the owner's professional representatives may be the construction expert. Moving the responsibility would align the responsibility for performance from the client who is buying the construction to the expert contractor who is providing the construction, thus making the contractor more accountable. This would make identifying and utilizing expertise much more important. This concept may be disruptive to the current industry of professionals because they do not currently have this capability.

A USAF engineer discovered by personal experience the resistance of professionals to the concept of using performance information. The current client centric industry and professionals have not had success in delivering high performing construction. For the past twenty years, the industry has attempted to utilize more expert vendor centric approaches such as design-build (DB), construction management at risk (CMAR), Private Public Partnerships and Job Order Contracting (JOC)] [(Egan, 1998; Grimsey, 2002; Grout, 1997; Hopper & Goldman, 2004; Hutton & Solis, 2009; Konchar & Sanvido, 1998; Kashiwagi, 2014a, p. 15.18; Kumaraswamy & Morris, 2002; Matthews & Howell, 2005; Nellore, 2001; Pietroforte, 2002; Williams, Young, Tzeyu & Murat, 2003; Wong, 2006). But the key to this paradigm shift is the identification and utilization of expertise and performance information. Without performance information, the result will continue to be litigation and higher construction costs.

USAF Performance Information Project

In 1980, a USAF civil engineer was attempting to identify the performance of a sprayed polyurethane (SPF) roof system (Kashiwagi, 1983) for installation at Holloman Air Force Base (AFB), New Mexico. The SPF roof system had the following advantages:

1. Lightweight [2.5 LB/CF].

2. Monolithic and manufactured by the contractor on the roof deck by mixing two liquids in an exothermic reaction.
3. Has a high insulating value [R value of 7 per inch] which stopped the movement of metal decks caused by heat in the southwest.
4. Could be installed directly on existing metal decks or existing roof systems.
5. Renewable with a protective coating.
6. Inexpensive when compared to the traditional built up roof system which was the USAF standard roofing system.

The USAF structural engineer/roofing program engineer identified that the SPF roof system did not perform and was not recommended on USAF facilities. Applications of the SPF roof system at any USAF base would require his professional approval. This was very discouraging and convinced the civil engineer at Holloman AFB not to proceed with the effort.

The USAF Civil Engineer office [office responsible for all civil engineering officer assignments] sent the civil engineer to Arizona State University (ASU) to get a civilian institute (CI) master's degree in construction management [he actually received an industrial engineering masters with a minor in construction management which is significant in the civil engineer's future career]. One of the requirements of the degree was to write a thesis that would improve the USAF construction program. The civil engineer decided to do his master's thesis on "identification of the performance of the SPF roof system based on performance information (Kashiwagi, 1983). The USAF engineer recalled that the expert of the SPF roofing industry was located in Tempe, AZ, where ASU was located. The project was to investigate why there was such a differing perception of the SPF roof system performance between the USAF roofing professionals and the SPF expert vendors. The engineer's thesis objective was to use the concept of performance information to identify the actual performance of the SPF roof system. A secondary objective would be to identify why there was such disparate concepts of performance of the SPF roof system. The third objective would be to identify if the USAF could use the SPF roof system to successfully protect USAF facilities. The civil engineer became a researcher. He started the investigation and quickly confirmed the following (Kashiwagi, 1983, p. 1 - 22):

1. No one in the roofing industry used extensive performance information.
2. No one had SPF roof performance information.
3. There were conflicting performance opinions from the USAF roofing program, USAF roofing consultant and from the SPF industry stakeholders [major SPF roofing contractors] depending on professionals and stakeholder experience.
4. The project was to create performance information that would end the disagreement.
5. The performance information could not have a preconceived bias. The collection of the performance information would have to be non-biased.

To ensure the accuracy of the information and to minimize bias of the performance information, the researcher personally collected the performance information. He would personally go through the files of SPF roofing contractors to randomly select the oldest roofs [without any idea of the performance of the roofs], inspect the roofs and collect and compile performance information which included customer satisfaction, roof performance duration and leak information.

The research identified that there was no motivation among USAF professionals to utilize performance information of construction services in the USAF. The creation of performance information would require a tremendous effort. It would require multiple sources of information, creating a new information structure of the performance and the identification and verification of high-performance SPF roof systems and contractors and the documentation of their installed roofing systems.

The researcher realized that the current professionals used their own experience to decide what the performance of different roofing systems were. The technical position of the professional in charge of identification of performance was not usually changeable or challengeable. The USAF roofing expert, ASU and the Air Force Institute of Technology (AFIT) education administrators offered no financial and information assistance on the project. The advantage of the researcher's CI AFIT [Civilian Institute AFIT] assignment was that his time was already paid for by the USAF as a part of the master's degree. Instead of the traditional one-year AFIT Civilian Institute assignment, the researcher was given two years [1981 – 1983] to finish his Master of Science (MS) degree in industrial engineering with a minor in Construction Management. The researcher was highly aligned and motivated to understand why professionals, who build their expertise on science, logic, and fact, had such diverse professional positions on building system performance. His objective was to identify why a professional or an expert vendor would be allowed by the industry to maintain an inaccurate position in a science-based profession [engineering and construction management].

The research's strategic plan was to (Kashiwagi, 1983, p. 16):

1. Identify if the SPF roof system had sufficient performance through documentation.
2. Identify if the SPF roofing contractors were sufficiently motivated to document and publish the SPF performance information.
3. Collect sufficient performance information to identify the performance or nonperformance of the SPF roofing system, to impact the perceptions of the USAF roofing professionals.
4. Write a SPF roof specification that could be used by the USAF civil engineers at the base level.

The USAF researcher received no encouragement or assistance from the USAF roofing engineer [and his professional roofing consultant] at the Engineering Services Center located at Tyndall AFB. The researcher was instructed by his thesis advisor that the thesis objective of using performance information to potentially impact the decisions by the USAF roof engineer and the USAF, was too optimistic and time consuming. The project professor at ASU felt it was interesting that the USAF technical experts were not in support of the research project [that would seem to benefit the USAF].

The research study objectives included (Kashiwagi, 1983, p. 16-22):

1. Identifying the performance of the SPF roof system from a large database of SPF roofs.
2. Identifying the impact of the environmental conditions in the installation of the SPF roofing system and the duration of its performance.
3. Identifying the differences between the performance of different types of SPF roof systems.

4. Identify if the results of the inspection of SPF roof system could lead to the improvement of the SPF system performance.
5. Identify if the resulting performance information of the inspected SPF roof systems could be used to change the USAF approach to utilizing the SPF roof system.

SPF Roof Inspections and Resulting Performance Information

The project used the following methodology in the research project (Kashiwagi, 1983, p. 45 - 62):

1. Roofs were randomly picked from contractors' or owners' files. Preference was given for older roofs and roofs in the geographical area that allowed the maximum number of roofs to be inspected.
2. Project participants were responsible to open their files and give the researcher access to all roofs, including putting the researcher on the roof and making the client available for performance questions.
3. Any industry participant could volunteer for the inspection of SPF roof systems.
4. The performance information would belong to both the contractor and the researcher.
5. The researcher would identify items of nonperformance and using his engineering background give potential solutions.

The researcher reached out to the SPF contractor industry and identified the following SPF contractor locations, SPF roof systems and weather conditions:

1. Phoenix, Arizona, silicone coating, dry arid environment.
2. Longmont, Colorado, silicone coating, snow/winter area.
3. Eau Clair, Wisconsin, silicone coating, four seasons including snow/winter.
4. Louisville, Kentucky and southern Indiana, silicone coating, temperate and four seasons.
5. Elizabeth, New Jersey, asphalt, and aggregate covering, four seasons including snow/winter. This roof system was inspected despite objections by industry participants.
6. College Station, Texas, urethane coating, four seasons.

The research study results included (Kashiwagi, 1983, p. 16; Kashiwagi, 1999):

1. Database of 1125 polyurethane foam (PUF) roof applications including roof area, number of penetrations, roof slope, roof traffic, ponded areas, areas of blistering/delamination and exposed SPF.
2. Inspection and documentation of 247 PUF roofs.
3. Performance information collected on the SPF roofs included: Customer satisfaction, maintenance performed, percentage deterioration of the system and required replacement, and the coating system performance under different environmental conditions.
4. Of the 247 roofs, 94% of the roofs inspected had less than 5% deterioration and 97% of the owners were satisfied with the roofs.
5. The highest performing SPF roof was the silicone coated SPF roofs. The urethane aliphatic roofs were performing; however, the urethane coating was reverting [going from one

component cured coating to the two original raw materials components]. It was later identified by the researcher that the aromatic urethane, made by a different manufacturer, was the highest performing SPF roof system, despite what the industry experts were stating [Kashiwagi, 1999].

6. A specification for installing the silicone coated sprayed polyurethane foam (SPF) which included the latest lessons learned from the silicone coated SPF roof system. [The specification was proposed to be used on two USAF bases].
7. An economic analysis model which considered the potential duration of the SPF roof system based on performance information and the insulating quality of the R-7 SPF roof system.
8. A vapor flow model to analyze the potential of saturation in the closed cell system. Even though the SPF was monolithic closed cell and waterproof and the silicone coating was a breathable coating [resist UV degradation of the SPF], standing water in areas due to a lack of slope and drainage acted as an impermeable waterproofing membrane. The standing water would then cause the SPF to get saturated in the ponded areas when there was an appreciable vapor drive moving from the inside to the outside of the building [Kashiwagi, 1995; Kashiwagi, 1991].
9. The SPF roofs were being installed in ¼ inch passes and was the source of blistering in traffic areas. The inspection identified that if the roof was installed in ½ inch passes the blistering problems in traffic areas would be severely minimized. This was one of the greatest contributions of the research to the industry [Kashiwagi, 1999].
10. The asphalt coated and aggregate SPF roof system was not recognized by the roofing contractor association as a legitimate SPF roofing system. However, the vendor and his roof installations met the requirements of the inspections. A quick engineering analysis identified that the roof system without the asphalt may be a high performance roof system. After getting the USAF researcher to sign off on a patent, a major SPF manufacturer applied and received a patent for the Aggregate Covered SPF roofing system [North Carolina Foam]. Later inspections identified that the potential flaw in the system was that because the SPF was not observable beneath the layered aggregate, the installation quality of the SPF was poor and led to potential blistering problems.
11. Taking the lessons learned from the research, the researcher produced a performance-based SPF specification and supplied it to a couple of USAF bases that could be used to procure SPF roof systems. The specifications were a performance-based specification [Air Force Office of Special Investigations District 7 (AFOSI), 1983].

Reaction of the Research by Arizona State University and the SPF Roofing Industry

The researcher was awarded a Master of Science Engineering (MSE) degree in December 1983 [2.5 years of research work]. The MSE research led to the most publications from an MSE thesis at the ASU Department of Industrial Engineering and from CI AFIT graduates. The University published the thesis and it was immediately edited by the researcher, recopyrighted and republished by SPF industry stakeholders [Kashiwagi, 1984]. One of the contractors also requested their own publication with their own performance information [Kashiwagi, 1985b]. The National Roofing Contractors Association (NRCA) published the research results, it was the first-time performance information of the SPF roofing system was published in two refereed international symposiums [Kashiwagi, Pandey, & Tisthammer, 1997; Kashiwagi, 1985a]. The

Journal of Thermal Insulation published the results of the thermal analysis and performance of the SPF [Kashiwagi & Moor, 1993; Kashiwagi & Moor, 1986].

The researcher's observations became industry standards and led to further inspections and research analysis [min ½ inch SPF passes, the minimization of ponded areas, the use of the aggregate SPF roof system] [Kashiwagi, 1996]. Two USAF bases [Nellis AFB and Williams AFB] utilized the thesis performance specification to procure SPF roof systems [AFOSI, 1983]. The thesis work impressed Arizona State University to bring the researcher back to complete his PhD work. The roofing industry was thrilled with the performance information and it led to a $1.3M performance study of the hail resistance of the Urethane SPF roof system [Kashiwagi & Pandey, 1998; Kashiwagi & Pandey, 1997].

The Response of the USAF Roofing Professionals

The response by the USAF roofing engineer was extremely different from the industry reception of the performance information. The USAF roofing engineer did not take kindly to the researcher's thesis results. He did the following [AFOSI, 1983]:

1. Recommended that the researcher's next assignment as the roofing instructor at the Air Force Institute of Technology (AFIT) school be rescinded.
2. Alerted the USAF Office of Special Investigation (OSI) [police and investigation arm of the USAF] and started an investigation on the researcher for "Conflict of Interest" and fraudulent information not in the best interest of the USAF. He was proposing that the research results were inaccurate and the researcher had not acted in the best interest of the USAF, may have been inappropriately compensated for his efforts and leaked classified USAF information to contractors on two USAF procurements [all his claims were found to be inaccurate by the USAF OSI].
3. Made derogatory and inaccurate personal statements about the researcher to the OSI investigators fueling the charges of "conflict of interest" and fraud.
4. Used his relationships and influence in the USAF, using commands and AFIT education group, to ensure the researcher's USAF career would end. He stated in his written statement to the OSI [and to the researcher in person] that the researcher would never be put in a position of teaching other USAF engineers.
5. In his entire statement to the OSI, the USAF roofing engineer did not address the research results of the SPF performance information. He stated that the performance information was biased. He did acknowledge that a couple bases were using the researcher's SPF performance specification to procure SPF roofs. The OSI investigator noted that the USAF roofing engineer's claims were confusing in that for a USAF base to use a SPF specification to procure a roof, he would have to approve the specification as stated by his own USAF roofing policy.

Due to the USAF Air Force Civil Engineering Center [AFESC] structural/roofing engineer's efforts, the reaction to the USAF civil engineering researcher's results was one of non-acceptance and an attack of the integrity of the research project manager and the researcher's integrity by the USAF roofing community. The researcher's next assignment to teach at the Civil engineering school was terminated due to the roofing engineer's recommendation. The USAF roofing engineer informed the researcher that he would not teach any USAF captain in the future. An Office of Special Investigation (OSI) investigation was opened on the USAF researcher claiming the appearance of the conflict of interest [receiving payment, giving unfair advantage to contractors competing on USAF roofing projects and providing fraudulent research study results]. Interestingly, the validity of the actual performance information results was not discussed by the USAF roofing community. The objective of the OSI investigation was to identify if the researcher had broken USAF regulations [acceptance of inappropriate funding] in doing his research work [AFOSI, 1983].

After a year's investigation, no evidence of wrongdoing could be identified by the OSI (AFOSI, 1983). The case was closed. A letter of reprimand was written to the researcher by his reporting officer, the Director at the Air Force Civil Engineering Center [AFESC], for being under the appearance of a "conflict of interest". The researcher was directed to discontinue all further research work with the SPF roofing system for three years. During the USAF OSI proceedings, the USAF researcher had no legal representation, was given no information and was pressured to take a polygraph test. Every industry person who assisted in getting access to the database of 1125 roofs, and 247 inspected SPF roofs was questioned for potential illegal payment and inappropriate actions with the USAF researcher.

The researcher was confused on why such a valuable research work resulted in an OSI investigation. The researcher could not understand why the USAF structural/roofing engineer used derogatory, biased and inaccurate statements to the OSI investigators [captured as a part of the OSI written record in the investigation]. Not once was the value of the SPF performance information noted by the USAF roofing engineer in his written statement. The researcher spent the next three years writing papers on his research investigations of the performance of SPF roof systems.

Despite an unblemished record [researcher was a Reserve Officers' Training Corps (ROTC) distinguished graduate (DG) and awarded a fully funded two-year master's degree at a civilian institution, assignments were normally only one year], the researcher lost his opportunity to become the roofing instructor at the USAF civil engineering school, and was forced to find another assignment. He was assigned to a civil engineering officer slot that required a master's degree with no job description. If the slot was not filled, the USAF Engineering Services Center (AFESC) would lose the position. In other words, the researcher was sent to a slot that had no job or what was known by other USAF officers as a "dead-end job".

The USAF research study results were controversial for the following reasons:

1. The results of the study conflicted with the current USAF 91-35 roofing policy for USAF facilities [set by the USAF roofing engineer].
2. The results went against the USAF roofing policy of restricting any SPF roof installations except in rare circumstances and would still require a USAF headquarters approval [AFESC structural/roofing engineer that originated the OSI investigation].
3. The decision by the USAF Roofing Engineer and the Industry roofing consultant utilized by the USAF roofing program [interview with Ed Schreiber, 1982 located in Detroit, MI] was to

utilize the traditional four ply built up roofing (BUR) system and not roofing systems such as the SPF roof system [which were identified as experimental and had no performance history]. This was based on their professional expertise and not performance information. They did not have the performance information on either the BUR system nor the SPF system to make a logical analysis of value [price and performance duration].

4. The information used to educate USAF civil engineers on the SPF roof system was inaccurate. It was based on professional technical expertise of the USAF roofing engineer and roofing program professional consultants.
5. The SPF roof system performance information collected in the research was the first performance information in the roofing industry and in the USAF roofing education and was not given to USAF engineers. Through the personal efforts of the researcher, two USAF bases agreed to use the SPF specification generated by the research project.
6. The number of roof inspections [247], the number of different environmental conditions of the inspected roofs [6] and the dominant performance results [97% customer satisfaction, 94% less than 5% deterioration], troubled the USAF roofing manager and AFIT roofing education program.

USAF Researcher Changes Technical Professional to Continue Research

The researcher was attempting to change the USAF civil engineering environment from an owner centric industry which utilized technical professional experts to manage, direct and control the quality of construction systems, to an environment where performance information could be used by owners to identify and utilize expert contractors.

In fairness to the USAF roofing community, they did not know how to discuss the value of the performance information. They resisted the researcher because he was attempting to change their paradigm. He was using performance information to challenge the expertise of professionals. Because of his actions, he was targeted. In normal situations, an USAF officer investigated by the OSI would not be promotable. He would never get a recommendation from his superiors to compete for lucrative career enhancing assignments.

An inherent problem with traditional environments that utilize professional technical expertise, is that different areas of technical expertise create silos. The civil engineering technical expertise was one silo in the Air Force Institute of Technology (AFIT) and taught all USAF base civil engineers. The roofing technical area was its own silo within the civil engineering silo. The AFIT roofing instructor was an MSE level professional who educated the lower-ranking officers who maintained facilities.

There was another silo which was the Industrial Engineering/Systems Engineering silo. This group educated USAF industrial and systems engineers to optimize USAF aircraft, communication and electronic systems. This silo utilized PhD level officers who understood the optimization of technology systems in the USAF and educated the higher-ranking officers and managers of the operational USAF systems. Normally each silo could control the progression of the USAF officers in their own silos. However, in this case, the USAF researcher who was using performance information in the civil engineering roofing area, was listed as an industrial engineer [MSE in industrial engineering] whose notable achievements in his performance information area of expertise caught the attention of the AFIT Industrial Engineering staff. His achievements met their requirements even though they were not appreciated by the civil engineering area (Kashiwagi, 2019, Chapter 7):

1. ROTC Distinguished Graduate (DG).
2. Successful completion of a Master of Science Engineering (MSE) Degree in Industrial engineering at Arizona State University with a minor in Construction Management [only officer in Industrial/Systems Engineering and Civil Engineering].
3. The highest publication record of any USAF MSE graduate at civilian institutes [five major publications in three years].
4. High recommendation of the ASU Industrial Engineering department due to his previous MSE performance. They promised the AFIT industrial engineering office that the researcher could finish his PhD on time in three years [huge risk of USAF PhD candidates in the civilian university programs].
5. A 99 percentile Graduate Research Exam (GRE) rating on quantitative section.
6. Assignment at the Air Force Engineering Services Center [high level command assignment] where due to his ingenuity and logic and IE degree, he identified the optimal solution of a $98M Runway Rapid Repair Program using a time-based simulation program (United States Air Force Officer Effectiveness Report, 1985). He also served a prestigious assignment to the Royal Saudi Air Force Peace Hawk/Shield Program in Riyadh Saudi Arabia as an USAF technical engineering consultant where he ended up saving the Royal Saudi Air Force (RSAF) $12.5M to stay within budget on their Peace Shield Command and Control project.

Based on his ability to produce significant results, the AFIT group identified the researcher in 1989 as the best officer candidate for a 1992 professor slot requiring him to get his PhD at Arizona State University in the Industrial Engineering department. His mentor and PhD committee were from the same academic staff who worked with him five years earlier on his MSE. The USAF researcher had sidestepped the USAF roofing engineering technical staff professionals and their resistance to using performance information and was now given another opportunity in the development of the use of performance information. The same AFIT organization that had terminated an assignment in the Civil Engineering office was now inviting the “persona non gratis” researcher back into the higher-level PhD position in Industrial Engineering as a system engineering researcher. The researcher became the only USAF engineering officer educated through the Air Force Institute of Technology (AFIT) civilian institute (CI) with 5.5 full years of education.

USAF Research Project Utilizing Performance Information

The aforementioned researcher did his PhD research project at ASU to investigate the utilization of performance information. A method for professionals to utilize performance information would have to be created. This would assist in overcoming the resistance in changing from a client centric to an expert vendor centric environment. The lessons learned to replace professional decision making to identifying and utilizing expertise included (Kashiwagi, 1991, p. 4 – 5):

1. The client's professional's decision making needs to be minimized to increase accuracy and efficiency in identifying and utilizing expertise.
2. Vendors should be required to provide performance information that identifies their value to meet the requirements of a unique project.
3. A process is required where the clients can get vendors to compete using the vendors' performance information. The easiest method to eliminate the biased decision making of professionals is to automate [minimizing all thinking and decision making where the professional's bias is utilized].

The USAF PhD thesis project was divided into the following tasks (Kashiwagi, 1991, p. 9 -12):

1. Create a simple explanation to differentiate the professional controlled and owner centric environment from the utilization of expertise to create a contractor or vendor centric environment.
2. Change the traditional owner centric procurement process to a vendor centric procurement process by replacing the decision making and direction and control of the professionals to the identification and utilization of the expertise of the best value vendor.
3. Minimize the amount of information needed for communicating the project requirement from the owner to the vendors.
4. Automate the normal selection of the best value vendor with a computer model that identifies the best value vendor.
5. Once the best value vendor is selected, the vendor is requested to provide a detailed schedule, a simple risk mitigation schedule, go through a technical review of their process and track the project time and cost deviation.

The scope of the research project was to create and run the new procurement approach to the selection of the best value vendor minimizing the decision making of the professional. It did not include Task 5 listed above. The project avoided any resistance of traditional professionals in the USAF. The entire research project was designed by the researcher and reviewed for technical competency by the Industrial Engineering and Construction Management committee at Arizona State University and the private sector client in Traverse City, Michigan. The researcher needed to prove that the approach could be technically run, before facing the expected resistance of industry professionals who previously had resisted the use of the performance information. The research project had the following deliverables (Kashiwagi, 1991, p. 297-323):

1. A best value procurement process.
    a. That could compare different products by different non-technical performance characteristics that could meet the client's requirement.
    b. That identified client's requirement in terms of value [price, performance, customer satisfaction].
    c. Used vendor's performance information from past projects.
    d. That identified the best value vendor for the unique project requirement.
2. Roofing performance criteria which included physical characteristics of the project roof, the energy savings of the competing roofs, the performance characteristics including roof service duration, warranty length, life-cycle cost, customer satisfaction, and roof leak prevention.

3. An automated selection process utilizing the Displaced Ideal Model (DIM) [Zeleny, 1982] which took the input of the performance criteria, the owners relative weights which represented the owner's requirement, and the information factor which was the relative amount of information of each performance factor [based on the relative spread of values, more information created by a larger spread of relative values].
4. An Industry Structure (IS) figure that explains the transformation from the low bid approach to the best value approach.

The strategic plan of the USAF researcher at the time of the PhD project was to:

1. Create the automated procurement system for the PhD dissertation requirement.
2. Run a case study to test the concept also to meet the PhD requirement.
3. As an instructor at the AFIT industrial engineering department, identify USAF systems requirements where the new automated procurement system could be tested to continually improve the new approach.

The client that ran the case study to test the concept was impressed by the capability of the approach to accomplish the following [Kashiwagi, 1991]:

1. Reduce the procurement time and cost.
2. Have different approaches and systems to compete against each other to create a value engineering event.
3. Minimize the need to have professional expertise on his staff.
4. Identify the best value considering all criteria without having to make decisions by having an automated system.

The test was successful. The ASU industrial engineering and construction management professors were impressed by the expertise of the researcher. The only question they had for the researcher in the defense of the thesis was "Who owned the information technology (IT) developed by the researcher?" The USAF industrial engineering department was interested only in the researcher passing his dissertation requirements in three years to become a professor. They were not accustomed to a PhD student developing a new usable technology. The ASU professors were amazed with the researchers capability to integrate the in-depth knowledge of the industry, a change of paradigm that had never been tested, and the ability to select and utilize an automated multi-criteria decision making model that automated the decision making of professional project managers. The researcher had become the expert.

In an attempt to get a patent on the developed technology, the researcher realized that the USA patent office could not understand the technology or the underlying logic. The realization was made that the technology [Information Measurement Theory (IMT) and Best Value Approach (BVA)] could not be easily understood or transferred. The researcher decided to utilize the licensing of the technology at ASU, instead of having endless discussions with the patent office. It has become the most licensed intellectual property (IP) technology developed at Arizona State University (ASU) [64 licenses over 28 years].

After graduating from ASU in 1991, the USAF researcher gave a presentation to his new industrial engineering (IE) department staff. He was impatient to start testing the automated procurement system on USAF system developments. He quickly found out that his USAF IE superiors were not oriented toward research tests to optimize and develop the USAF systems. They were oriented toward teaching USAF IE professionals the technical structure they could use to replace the current professionals. They were not interested in changing the paradigm of replacing the professional decision making with the identification and utilizing expertise with performance information.

At the same time, the USAF was downsizing due to the bringing down of the Berlin wall and the end of the cold war with the Soviet Union. The overall USAF created a very attractive option that allowed the researcher to leave the USAF. In six months, the researcher became a research director at Arizona State University and within two years created the Performance Based Studies Research Group (PBSRG) and started running tests utilizing the new information-based procurement system.

The “Economic Feasibility of the SPF Roof System” [USAF Performance Information research project] and the “Performance Design/Procurement System for Nonstructural Facility Systems” became the beginning of an effort to reshape the supply chain, change the project management model [from manage, direct and control to identify and utilize expertise], change the risk management model [minimize decision making, transfer risk to mitigating risk] and move toward the automation of the delivering of services. Over the next 28 years, the name of the approach changed from the Best Value Procurement to the Performance Information Procurement System (PIPS), and then to the Best Value Approach (BVA).

Creation of a Research Platform PBSRG for Disruptive Technology

PBSRG research is in the following areas (Kashiwagi, 2019; Kashiwagi, 2020):

1. Changing environments from owner centric to vendor centric.
2. Changing the project management (PM) model from decision making, management, direction, and control to identifying and utilizing expertise.
3. Redefining risk and identifying the source of risk as stakeholders who make decisions. A major part of redefining risk is to identify that the expert vendor does not have risk and mitigates risk caused by the nonexpert stakeholders.
4. Optimizing the supply chain by the identification and utilization of expertise and the use of performance information.
5. Transforming the stakeholder communication from professional expertise using detailed technical information to the language of non-technical metrics that minimize decision making.
6. Optimize the Best Value Approach (BVA) to reduce the cost and time of services.

PBSRG is a unique research center. It is led by a Director who created the Information Measurement Theory (IMT) and the BVA and the IP technology that is the most licensed IP developed at ASU. PBSRG research, using IMT concepts, have shown the ability to simplify complexity and has continually created methods that cut costs and increase value. PBSRG is structured to do the following (D. Kashiwagi & J. Kashiwagi, 2019):

1. Use the CIB [international council of research and innovation in building and construction] W117 working commission to integrate worldwide research of the BVA in countries around the world.
2. Host the CIB W117 journal to ensure the most recent BVA results are immediately published and that BVA experts are utilized to peer review papers.
3. Continually run industry tests on BVA research concepts throughout the world.
4. Work only with visionaries who want to test the concepts of BVA. By working only with visionaries, PBSRG minimized the resistance from stakeholders who are attempting to protect the traditional practices of using professionals and who lack the capability of changing the paradigm.
5. Have flexibility and control over PBSRG research direction. When the BVA research identified that the biggest opportunity to change was in project management and not the professional engineering area, PBSRG research moved from Arizona State University Civil Engineering department to the SKEMA Business School Project Management dBA program. PBSRG is unique because the founder and inventor is a part-owner of the PBSRG research technology and is the only academic research group that licenses the intellectual property (IP) [through Arizona State University].

PBSRG Projects that Developed the Use of Performance Information

The development of performance information took place in the following research projects:

1. USAF master's thesis SPF roof system performance (Kashiwagi, 1983).
2. USAF PhD procurement test (Kashiwagi, 1991).
3. State of Hawaii (Kashiwagi & Savicky, 2003; Kashiwagi & Mayo, 2001a; Kashiwagi & Mayo, 2001b; Kashiwagi, Savicky & Parmar, 2003).
4. State of Utah (Kashiwagi & Byfield, 2002a; Kashiwagi & Byfield, 2002b; Kashiwagi & Byfield, 2002c; Kashiwagi & Byfield, 2002d).
5. Dutch Fast Track Projects and Implementation of the BVA (D. Kashiwagi, J. Kashiwagi, 2011; Van de Rijt, Witteveen, Vis & Santema, 2011).
6. US Army Medical Command (Kashiwagi, D., Kashiwagi, J., Smithwick, J., Kashiwagi, I., Kashiwagi, A., 2012; J. Kashiwagi, Sullivan & D. Kashiwagi, 2009).
7. State of Oklahoma tests.
8. State of Minnesota Construction Projects (Kashiwagi, D. et al., 2012).
9. Neogard Alpha Program (Gajjar, D. Kashiwagi, Sullivan, & J. Kashiwagi, 2016; Gajjar, Sullivan & Kashiwagi, 2013; Gajjar & Kashiwagi, 2020; D. Kashiwagi, Gajjar, Kashiwagi, Zulanas & Dhaval, 2017; Kashiwagi, Gajjar, Kashiwagi & Sullivan, 2015; D. Kashiwagi, Smithwick, J. Kashiwagi & Sullivan, 2010; Kashiwagi & Tisthammer, 2002; J. Kashiwagi, & Sullivan, 2016).
10. New Alpha Program (https://cibw117.org/the-alpha-certification-program/).

USAF First Research Project Establishes Client Centric Environment That Cannot Utilize Performance Information

The first research test identified by the construction industry was a client centric environment. Clients utilized professionals to deliver services. These professionals used the traditional structure or silos to make their decisions that resulted in the delivered service. Although the professionals were educated in the sciences, the lack of information caused them to build a structure of experience, subjectivity and decision making. The environment is inductive and probabilistic. It required decision making by professionals using their experience. The professionals used their expertise, tenure and decision making to resist change. The client centric environment was described with the following observable characteristics:

1. Professionals are educated, and certified to utilize their experience to govern the client centric environment.
2. Professionals identify and create the service requirements and then control the delivery of the service.
3. Professionals use specifications to direct contractors.
4. Performance information collected by observation is not utilized by professionals.
5. Client centric environment is cost based using minimum specifications.
6. Client centric environment assumes that contractors who meet the minimum standards are all the same.
7. Client centric environment requires licensing, bonding and insurance to minimize risk.
8. All projects have risk.
9. All contractors have performance risk.
10. Performance information of construction systems is not utilized in a client centric environment.

The SPF roof system performance was resisted by the USAF environment because the USAF was a client centric governed environment utilizing professional expertise. Despite the resistance of the USAF management level professional, it was quite unusual to have two USAF bases civil engineering deputies use the researcher's specification on SPF roof installations and attempt to install the SPF roofing system against the USAF roof policy. The researcher's expertise was not utilized further due to the control placed on the researcher by the USAF roofing professionals.

Users of Performance Information Are Resisted by Structure of Professionals

The researcher overcame the resistance by being focused and working on publications and application of performance information in industrial engineering applications. The researcher had an uncanny capability to use performance information that resulted in large savings in project cost. He optimized the value of the USAF $100M Rapid Runway Repair program by running time simulation. He followed it up by making a $12.5M saving through a design change in the Peace Shield Royal Saudi Arabia command and control system [United States Airforce, 1988]. Ironically, the researcher's skills used a new approach. His expertise did not need experience, relationships or time to have an impact on the USAF structure. He used performance information to easily solve problems caused by USAF professional decision making [United States Airforce, 1988].

He returned to the research arena to create the automated procurement system that utilized performance information. He continued to use major lesson learned from the first research test:

1. Find and work only with visionaries who could see into the future.
2. Create and run an automated procurement system that utilized expert vendor performance information to minimize decision making by professionals.

The automated delivery system test was successful. To do further testing, the research had to be taken outside of the USAF bureaucracy run by professionals which did not have interest in testing disruptive technology to optimize the performance of USAF systems.

Rules for Disruptive Technology Research

The use of performance information is a disruptive technology. Implementation of performance information is disruptive because it minimizes the work of professionals and redefines the definition of expertise, risk and mitigation of risk. A new research platform is needed with completely different rules. The new research structure was created from the Information Measurement Theory (IMT). This created a completely different set of rules for the research. IMT is a deductive logic that included the following concepts (Kashiwagi, 2014a):

1. Stakeholders are divided into observant [can see into the future] and nonobservant [cannot see into the future].
2. The majority of stakeholders are non-observant.
3. Observant stakeholders minimize thinking, decision making and passing information.
4. Influence and control are inaccurate concepts that is understood by the observant.
5. Individuals control their own destiny. They act and are not acted upon.
6. Decision making is inefficient and ineffective and based on what is not known.
7. Collaboration with non-observant stakeholders is nonproductive.
8. The BVA is an approach that minimizes the effort of professionals. The concepts are similar to automation. Automation is popular because it minimizes human activity, lowers cost and increases performance.
9. The future is one of efficiency and effectiveness. It aligns with automation.

A new platform based on the above concepts was required to successfully test the disruptive technology. PBSRG was created for the future and not for the present. It required the following capabilities:

1. A School where the School Director gave full support to the innovative research [School of Construction Management at ASU]. The researcher enjoyed the Director's "no rules" approach to research. No permission was required for any research activity. The researcher became the only staff to be promoted to full professor in the School of Construction in 20 years.

2. Did not require assistance from the academic research community [whose objective was to sustain the role of professionals in government]. Required a different source of research funding.
3. Partner with industry visionaries who needed to reduce cost, increase quality and minimize the need to manage and control the vendors.
4. Be a worldwide research group to increase the probability of finding visionaries. Avoid resistance of the traditional professionals.
5. Be the only research group to run industry research tests and publish the results in an international journal which PBSRG could publish quickly and continuously.
6. License the BVA Intellectual Property (IP) through a major university.
7. Control the IP by the constant improvement of the IP.

The Performance Based Studies Research Group (PBSRG) was created in 1994. PBSRG has the following metrics in the areas of industry tests, publications, licensing and the first crossover research group in construction management which moved IP concepts from the construction industry to all industries. PBSRG utilized the performance information metrics to show its capability to optimize the supply chain in all industries (Duren & Doree, 2008; D. Kashiwagi & J. Kashiwagi, 2019; Kashiwagi, 2014b; Rivera, 2014; State of Hawaii PIPS Advisory Committee, 2002):

1. Duration of PBSRG: 1994 – 2020 [26 years].
2. Integrated PBSRG with the CIB [International Council of Research and Innovation in Building and Construction] working commission W117 "Use of Performance Information in the Construction Industry" in 2008.
3. Research Funding: $17.6M [industry visionaries and not government research funding]
4. Prototype Testing: 2,000+ tests with industry, ten different countries, $6.6B of services delivered [construction, IT, consulting services].
5. Industry research tests measure 98% client satisfaction, minimized cost [5 – 50%], and minimized contractor time and cost deviation to less than 1%.
6. 350 refereed journal papers, conference publications and books.
7. Director moved PBSRG, to the private sector in 2017, then moved the academic research to the SKEMA Business School Project Management dBA program [Doctor of Business Administration] in 2019.
8. Licensed Intellectual Property (IP): 64 licenses [1997 – 2020] [most licensed IP technology at Arizona State University].
9. IP included: Performance Information Procurement System (PIPS), Performance Information Risk Management System (PIRMS), Best Value Approach (BVA).
10. Research areas include information based and automated project management, information-based risk management, supply chain optimization, language of metrics, vendor performance metrics and the Best Value Approach (BVA).

Using the Automated Best Value Procurement (BVP) or Performance Information Procurement System (PIPS)

The first two major tests of the automated BVP and PIPS were the State of Hawaii (Kashiwagi & Mayo, 2001a; Kashiwagi & Mayo, 2001b; Kashiwagi, Savicky & Parmar, 2003; Kashiwagi & Savicky, 2003) and the State of Utah (Kashiwagi & Byfield, 2002a; Kashiwagi & Byfield, 2002b; Kashiwagi & Byfield, 2002c; Kashiwagi & Byfield, 2002d). The State of Hawaii utilized the approach on installing roofing systems. The State of Utah utilized the approach on procuring large general construction projects and the selection of architectural designers and engineering firms. Both were highly successful in delivering projects on time, on budget and meeting customer satisfaction. However, the client and expert contractors and designers made the following perceptions:

1. There was confusion on what was performance information.
2. The client was doing too much work keeping track of the performance information.
3. The client was responsible for collecting the performance information.
4. The client had to ensure that the performance information was accurate.
5. Client had to decide what information was not valid.
6. Client had to decide how to enforce the performance information in the project.
7. Client had to legally identify what was performance and what was not performance on a project. If the client was not happy with the project, the project performance of the vendor became a subjective rating.
8. Vendors were not sophisticated enough to understand why the automated Displaced Ideal Model (DIM) picked one contractor over another.

In both cases, the State of Hawaii and Utah industries resisted the best value procurement system even though the procurements were very successful [fast and efficient] and the best value vendors and clients were satisfied. Resistance was in the form of official protests of project awards, legislative hearings, questions in education hearings, charges that PBSRG at ASU was controlling the state's procurement of services [Dooley, 2002a; Dooley, 2002b], charges of conflict of interest of the BVA delivery system, articles in the local paper and official legislative inquiries. Besides the visionaries, industry professionals rejected using performance information to differentiate performance. Of the first four visionaries who successfully utilized the BVA, four of them were let go from their positions [state of Hawaii, Utah, Oklahoma and University of Minnesota]. As in the first two performance information tests, the BVA delivered high quality and lower prices, customer satisfaction and on time and on budget construction. However, the client risk was very high due to the industry resistance. The industry did not understand the paradigm shift.

The professionals and their structure of governance resisted the change of paradigm. They were not open to replace their decision making with performance information and moving the governance to the expert contractor/vendor. When clients attempted to use the performance information in the professional's service, the professionals used their relationships to politically remove the visionary. The personal experience of the USAF professionals removing the researcher and his performance information approach was only the first of many examples of the resistance of professionals.

Source of Risk [Project cost and time deviation]

Four major projects, the Dutch Fast Track Projects, Figure 2, (D. Kashiwagi, J. Kashiwagi, 2011; Van de Rijt, Witteveen, Vis & Santema, 2011) the US Army Medical Command Project (Kashiwagi, D., Kashiwagi, J., Smithwick, J., Kashiwagi, I., Kashiwagi, A., 2012 ; J. Kashiwagi, Sullivan & D. Kashiwagi, 2009) and the State of Minnesota projects, Table 3, and the State of Oklahoma, Table 2, had an unexpected impact on performance information.

Table 2: State of Oklahoma Performance Metrics (PBSRG, 2020)

Performance Measurements	**2008-2012**
State savings with best value projects (budget-actual)	$29,887,034
# of projects procured through BV	15
Value of Projects awarded through BV	$54,191,767
Success Rate defending Bid Protests (# of protests won / # protested)	100% (3/3)
Percent where BV Vendor was Lowest Cost	92%
Budget Deviation after award	-0.003%
Schedule Deviation after award	0.5%
Procurement Process Satisfaction	**All Projects**
Using Agency Satisfaction with the Traditional Process	6.0/10
Using Agency Satisfaction rating with BV process	9.5/10
Vendor Satisfaction with the BV process	9.8/10

Table 3: MEDCOM and Minnesota performance metrics (PBSRG, 2020)

Division Overview	**MEDCOM**	**Minnesota**
Original projects budget	$ 973,939,615	$ 495,094,925
Estimated cost over budget	$ 53,595,264	$ 38,828,396
Original Project Duration	228,402	50,463
Days Delayed	93,944	18,640
Total Number of Projects	619	424
Average Project		
% Over Awarded Budget	5.50%	7.84%
% over budget due to owner	4.13%	6.68%
% over budget due to Designer	0.06%	0.01%
% over budget due to contractor	0.00%	0.65%
% over budget due to unforeseen	1.31%	0.50%
% Delayed	41.13%	36.94%
% Delayed due to owner	30.84%	26.93%
% Delayed due to Designer	0.25%	2.00%
% Delayed due to contractor	1.48%	3.64%
% Delayed due to unforeseen	8.57%	4.36%

Party	Occurrence	%	Extra costs %	Extra time %
Rijkswaterstaat *Project teams, departments, road districts, traffic centrals*	245	88.4%	90.3%	57.4%
Provinces	2	0.7%	0.1%	0.0%
Water boards	3	1.1%	0.5%	0.0%
Municipalities	4	1.4%	0.4%	0.0%
Stakeholders in the environment *E.g. a gas company, the planning authority, cables and pipes managers*	19	6.9%	8.3%	25.0%
Rijkswaterstaat	**271**	**98.6%**	**99.5%**	**82.5%**
Contractors	**4**	**1.4%**	**0.5%**	**17.5%**
Total	277	100.0%	100.0%	100.0%
Total compared to planning			*18.2%*	*9.6%*

Figure 2: Rijkswaterstaat Fast Track Projects (Witteveen & Van de Rijt, 2013)

The four projects identified that over 90% of all project deviations were caused by the client's professionals decision making. The risk caused by the contractor was less than 1%. The combination of the two metrics led to the following conclusions and changes in the definition of project performance and performance information:

1. The source of risk was client's professional's decision making.
2. The expert vendor who is required to have a detailed plan from beginning to end [preplanning], and a milestone schedule to identify and mitigate risk and track time and cost deviation from beginning to end has no risk.
3. If a project was non-performing, the probability that the non-performance was caused by the vendor was very low. Therefore, nonperforming project ratings were non-representative of a contractor's performance and meaningless in predicting the contractor's performance on a future project which the best value approach (BVA) was utilized.

The purpose of performance information is to minimize project risk. Project risk is minimized by expert contractors who can identify a detailed schedule of work from beginning to end, a milestone schedule to mitigate risk caused by stakeholder decision making and unforeseen events, and prove that they have successfully done similar projects with similar characteristics. The impact of these tests on the construction industry include:

1. Contractors should not be held liable for past project poor performance.
2. Contractors should not be prequalified.
3. Contractor performance information should come from the contractors and the information should have specific characteristics depending on the future project.
4. Contractor performance information is not the responsibility of the clients or the construction industry.
5. Contractor performance information is unique and should identify if contractors are qualified for a unique project.
6. Contractor performance information does not need to be verified until a contractor is being considered for award of a specific project.

Alpha Programs

A Sprayed Polyurethane Foam (SPF) roofing system manufacturer was introduced to the best value environment and the Industry Structure (IS) logic. The manufacturer did not participate in the first USAF SPF performance information project in 1982. The manufacturer produced an aromatic urethane coating Permathane which exhibited hail resistant characteristics. Aliphatic urethane coated roofs which were inspected at Texas A&M University in College Station Texas in the first research project. The aliphatic urethane roofs were erroneously identified by the professionals as the roof coating that performed due to its resistance against ultraviolet degradation. However, the aliphatic urethane roofs that were inspected exhibited reversion of its coating [the two-component urethane reverted to its original two liquid components] [Kashiwagi, 1996]. The urethane coating that performed was the manufacturer's aromatic urethane coating. It had high performance with hail resistance and durability. The manufacturer approached ASU to do the following (Kashiwagi & Tisthammer, 2002):

1. Create performance information based on performance periods and hail resistance. Use performance information [ability to resist hail stones] to differentiate their Permathane roofing system from other roofing systems. Conduct field hail tests with aged roofs to show that the Permathane system could resist Factory Mutual (FM) size hail without damage to the roofing system. Large hail was causing roofing failures, PBSRG was also requested to identify if the Alpha roofing system could possibly resist larger hailstones.
2. Create an education program for the manufacturer to educate best value clients. Use the Best Value Approach to identify clients who are looking for the best value solution. The alpha system performance information would be a unique marketing program.
3. Educate facility owners with the BVA technology and convince owners to use the Best Value procurement system to buy roofing and coating systems. The manufacturer would then respond to the owners with their best value options.
4. Create a new Alpha SPF contractor program based on performance. The contractors would go through an inspection of their installed SPF roof systems to show performance. The manufacturer hoped to get the best contractors in the country to join their program. The contractors would be key in the success of their Alpha program. Contractors would have to maintain a 98% of roofs not leaking and customer satisfaction to keep their Alpha certification in the program.
5. Risk reduction for the manufacturer and the contractors. The manufacturer wanted to increase their warranty period from 10 to 15 years for this program. The manufacturer increased the thickness of the urethane coating and added a layer of #11 granules in the topcoat of the coating. The Alpha manufacturer also required a high-quality SPF manufacturer to produce a 3PCF SPF and call it an Alpha SPF which was only available to Alpha contractors.

The manufacturer's visionary was confident that the education would identify owners in the Best Value environment where competition would identify the Alpha roofing system and their other waterproofing systems as the best value product. The BVA education program by PBSRG/ASU identified or assisted the State of Hawaii, United Airlines, the University of Kentucky, L3 and DISD to install high performance waterproofing systems. One of the flaws of the Alpha program was the requirement for PBSRG to give all presentations to clients. The manufacturer did not have visionaries who understood the approach. This resulted in the termination of the program as the manufacturer's personnel's lack of understanding of the BVA led them to act in a traditional relationship manner with both contractors and clients.

The largest client who bought the Alpha roofing system was the Dallas Independent School District (DISD). DISD competed the Alpha roof system against the installation of new BUR systems or modified bitumen roof systems. The advantage of the Alpha system was it could be installed over the existing roof system, whereas the competing modified Bitumen systems required a complete removal and replacement. The DISD had two bond programs in 2005 and 2015.

The weakness of the Alpha SPF roof system was that it was a high-tech system that required contractor expertise. the Alpha contractors were scattered all over the country, and in the Dallas area, the Alpha manufacturer did not have enough high performing contractors to meet the DISD roofing demand. Instead of minimizing their risk and using the only experienced Alpha contractors, ensuring that the roof installations were high quality, the Alpha manufacturers allowed lower performing and low priced contractors with practices which increased the risk of premature failure of the Alpha roof system (Kashiwagi, Zulanas & Dhaval, 2017). the Alpha roof system manufacturers was also constrained by the following:

1. Weather constraints. The Alpha roof system could not be installed in wet, cold or windy environments.
2. Required expert SPF applicators who were highly trained and experienced.
3. SPF manufacturing production capability. The Alpha SPF manufacturer did not have the capacity to service all the contractors. Some of the lower performing contractors were forced to use substandard SPF.
4. Many of the DISD projects were controlled by general contractors. The SPF contractors did not have the capability to communicate their constraints and coordinate with the general contractors. They received no project management help from the Alpha manufacturer's representative.
5. The president of the manufacturer was the visionary. However, he did not have visionary operations people supporting the Alpha program. The amount of roofing required by DISD overwhelmed the Alpha manufacturer's representatives. They were paid a high commission for every gallon of material that was installed. They were not disciplined enough to maintain the Alpha specification and inspection requirements. The organization saw success as high sales and did not recognize the high risk of nonperformance.
6. The perfect storm was created when a new contractor was created from one of the existing Alpha contractors. The manufacturer accepted the new contractor if they had the same expertise as the contractor they came from. The new Alpha contractor started to bid a very low price and ended up installing 65% of all roofing applications, many of the roofs being substandard.
7. The DISD representatives were not blameless. Due to a lack of funding for their identified requirements, they lessened their requirement to cut costs. Instead of buying the Alpha system, they bought a ten-year Permathane system. They expected the same high quality and performance as the Alpha system. The manufacturer's representatives did not ensure that the Alpha system level of quality was met.

Instead of the Alpha SPF roof systems lasting 20 years, roofing issues started occurring within 5 to 10 years. The roofing manufacturer was now faced with a situation with honoring the warranty and fixing the Alpha roofs that were damaged. The manufacturer did not have a cash reserve to handle problems. The manufacturer's sales/warranty personnel had already been paid a generous commission without doing their responsibility. The low bidding contractor had formed a relationship with the manufacturer and stayed in business by fixing problems with the cash infusions from new projects. The client's representative had a relationship with the Alpha manufacturer and the contractor. The Alpha program was now resembling a traditional supply chain where relationships were being used to resolve issues with low performance installation.

The DISD roofing representative expected the manufacturer to fix their performance issues. The low performing Alpha contractor did not meet their obligations [went bankrupt]. Because of the issue with the SPF roofs, the DISD decided to remove all SPF roofs when repairs were required. The Alpha manufacturer was forced to terminate the Alpha program. The contractor who had caused the most problems declared bankruptcy. At the time of termination, there was three contractors who were still highly successful. Only one of the high performing contractors was in the Dallas area.

The three contractors did not depend on the Alpha program for their success. They used the Alpha program to get better product and performance from the Alpha manufacturers and they used the information system of the Alpha program to minimize the risk of their installed roofing systems. The other contractors depended on the Alpha program for business opportunities. Two of the high-performance contractors did not participate in the DISD roof opportunities in Dallas and California.

The Alpha program was terminated because of the following issues:

1. All contractors were treated the same by the manufacturers. PBSRG recommended numerous times to use the performance of the vendors to differentiate the contractor performance and quality which would motivate the high performing contractors due to the recognition and minimized cost of the manufacturer's warranty for the performing vendors. The manufacturer refused.
2. The manufacturer's representatives could not tell the difference. The personnel in charge of sales, inspection of contractor quality and warranty were not skilled or professional. They were not project managers who could implement a BVA system. They did not do their quality assurance of the BVA. They could not identify and utilize expertise. They did their business based on relationships. Yet they were rewarded with high commissions of the Alpha program.
3. The manufacturer could have protected themselves against the risk of nonperformance of the contractors by doing their quality assurance, requiring a weekly risk report (WRR). They should also have created a risk fund instead of paying the high commissions to the sales representatives. The manufacturer thought that the success would change the representatives to learn the Alpha program and become more professional in their approach. IMT identified this as an error in the manufacturer's approach.
4. The poor performing contractors could not tell the difference. They did not price their product as a performing product. They were financially unsound. They also did not mitigate

risk with a milestone schedule and Weekly Risk Report (WRR). Their project management was ineffective and low performing. PBSRG recommended to the manufacturer, that it would be worth the investment to assist the contractors in their project management practices. The manufacturer did not see the value of the advice until the manufacturer's financial risk increased.

5. Some contractors which met the Alpha program requirements, and who were perceived as good contractors by the industry, did not put their most experienced and performing people on Alpha projects. On one project, a client selected the Alpha roofing system based on the performance information. They installed a decent roofing system, however there were roof issues which the contractor did not efficiently resolve. The contractor wanted the Alpha coating and Alpha SPF manufacturer to pay for the materials [even though they erred in the application]. On the subject project that they did not respond in a timely manner, the Alpha program ended up losing a project worth upwards of $2M. PBSRG was forced to find another performing manufacturer to set up a similar program to the Alpha program to provide for the nationwide client.

PBSRG identified the reasons for the lack of the sustainability of the Alpha program:

1. Manufacturer could not tell the difference in levels of performance of the Alpha contractors.
2. Lower performing contractors could not tell the difference between the value Alpha system and their regular installations. They charged the same price for both.
3. Clients who used the BVA to procure Alpha systems could not tell the difference in performance between the high performing and low performing Alpha contractors. They assumed that all the contractors would perform to the same level of high performance.
4. Manufacturer's representatives were getting commissions that they did not earn. They did not enforce the Alpha system requirements on the contractors by doing their quality assurance responsibilities.
5. Manufacturer of the SPF did not meet their requirement of providing product to the contractors they did not have a good relationship with.
6. PBSRG did not have the authority to enforce the Alpha program requirements on the manufacturer's representatives.

The Alpha program was not aligned to the best value environment. It had some of the characteristics of the best value program, but many of the characteristics of a client centric, price-based system. PBSRG did not think that the Alpha program had a future in the SPF roofing industry. However, they were surprised by one of the performing Alpha contractors.

New Alpha Program

At the time of the termination of the Alpha program, the researcher identified that three of the six contractors had the following practices (Kashiwagi, Zulanas & Dhaval, 2017):

1. Serviced all their clients.
2. Could meet the 98% roofs not leaking and customers satisfied.
3. Keeps an information system.

4. Was not participating in the Alpha program to generate work.

Only one of the Alpha contractors understood the value of the Alpha program performance information structure and approached PBSRG to change the Alpha Program from a manufacturer controlled program to a contractor centric program [Insulated Roofing Contractors, IRC, located in Indiana]. They wanted the following characteristics in their program (https://cibw117.org/certified-alpha-contractors/):

1. Contractor based program.
2. Increased investment in time [in business for ten years] and performance [tracked their performance of installed roofing] for contractors.
3. Contractor controlled.
4. Contractor is responsible for tracking information and using the Alpha program for quality assurance.
5. High performance: 98% contractor satisfaction and roofs not leaking.
6. Contractor is responsible for warranty whether the warranty is being offered by the manufacturer or the contractor. Contractor is the single point of responsibility to the client and responsible for fixing any problem.
7. The focus is on customer satisfaction and value. IRC understood that this was the definition of transparency.
8. Tracking the performance information is a requirement for the contractor. The contractor is responsible for setting up the system and responding to any issues. The cost of posting the information on the Internet by a third party would be the responsibility of the contractor.

IRC knew that in order to be sustainable, they had to get a fair profit for their product. It would have to be a performing product, and it would have to be supported by the capability to constantly and consistently install the product. IRC was interested in scale. Instead of competing with other vendors where there was no competitive advantage and a very costly procurement process, they were interested in setting up a best value environment where they had the competitive advantage. The competitive advantage was:

1. Performance.
2. Price.
3. Customer service utilizing the internet, information systems and virtual integrated applications.
4. Efficiency, effectiveness and customer satisfaction.
5. Information based.
6. Scalable, repeatable, high performing.
7. They picked the market of roofing for schools as the primary marketplace.
8. They participated in a cooperative procurement group, marketplace where they identified the level of performance [which included the price].

IRC identified the cooperative marketplace where schools could go to the cooperative and buy roofs directly. Other roofing contractors could also be listed; however, they must meet the requirements of the Alpha program listed above. It cuts out the risk, complex and professional based procurement systems, and allowed guaranteed delivery of high quality every time. Their performance is constantly guaranteed by their performance information. IRC used the highest quality products and is responsible for the funding to set up their information-based customer service and the quality assurance by an independent third party.

The figures below are the latest performance information that all clients have access to on the internet. The new Alpha program [IRC] shows the optimal use of performance information, and gives the best value, with risk mitigated by their expert service. This is the latest and most accurate use of performance information in the delivery of service.

IRC discovered that the traditional procurement process is too expensive and filled with decision making by professionals [technical designers and procurement professionals] for performing expert contractors to participate on a regular basis. They moved to the best value quadrant. To move into the best value environment, they required high performance [and performance information]. They realized that they needed to act as the expert vendor who takes responsibility for any errors in application. IRC does all the quality control and has an independent third party [PBSRG] doing the quality assurance. They have eliminated the decision making of professionals in this supply chain.

Table 4: IRC Annual Performance (https://cibw117.org/certified-alpha-contractors/)

No	**Survey Results**	**Unit**	**2019**	**2017**	**2015**	**2013**
1	Total number of different clients	#	40	12	27	24
2	Total number of roofs surveyed	#	293	72	90	89
3	Total roof area	SF	21,634,918	7,915,423	2,286,230	5,428,887
4	Largest roof area	SF	1,037,600	1,037,600	140,000	759,500
5	Average roof area	SF	73,839	109,936	25,403	60,999
6	Oldest roof	Years	44	31	16	31
7	Average age of roofs	Years	15	13	8	7
8	Age sum of all projects that never leaked	Years	2,661	804	680	688
9	Age sum of all projects that do not leak	Years	4,201	944	698	858
10	% of roofs that do not leak	%	100%	100%	100%	100%
11	% of roofs with satisfied clients	%	100%	100%	100%	100%
12	% of roofs with clients that would purchase again	%	100%	98%	100%	100%
No	**Inspection Results**	**Unit**	**2019**	**2017**	**2015**	**2013**
1	Total number of different clients	#	10	6	12	6
2	Total number of roofs inspected	#	52	28	30	33
3	Total roof area	SF	8,037,065	7,154,944	2,095,986	4,025,462
4	Average roof area	SF	154,559	255,533	69,866	121,983
5	Oldest roof	Years	44	31	26	27
6	Average age of roofs	Years	21	24	11	10
7	% of inspected roofs with < 5% ponded water	%	100.00%	100%	100%	97%
8	% of inspected roofs with < 1% deterioration	%	100.00%	100%	100%	97%
9	% of inspected roofs with > 1/4" slope	%	96%	79%	97%	94%
10	% of inspected roofs' area blistered	%	0.06%	0.03%	0.02%	0.02%

Conclusion

In the last 28 years, research on performance information has resulted in the development of the Best Value Approach (BVA) that identifies and utilizes the expertise of expert vendors. The research has also developed the Information Measurement Theory (IMT) concepts that explain why the performance of the construction and other industries has not met expectations over such a long period of time. the BVA and the IMT research has led to the following conclusions:

1. 90% of all project risk [time and cost deviation) is caused by the client and their representatives.
2. A performing industry is expert vendor centric [the expert vendor is the most important and leads the project].
3. An expert vendor makes fewer decisions [decisions cause risk].
4. Performance is the identification and utilization of experts who mitigate risk, lower cost and higher value.
5. True competition increases quality and lowers cost. Most competition is not fair or accurate competition. It requires professionals to make decisions and is relationship based. This is the biggest source of risk in projects.
6. The existing industry environment is a client centric, where the client uses professionals [who meet education, certification and experience requirements] where the professionals attempt to identify the project requirement, select the best option via low price, and then manage, direct, control and inspect the vendor's work to mitigate the risk.
7. The change from a client centric to a vendor centric environment minimizes the need for professionals who represent the client to do any project management or quality control. Professionals should only be technical experts in their area of expertise. Professionals must minimize their decision making which causes project risk.
8. Professionals do not use or understand performance information. Their environment is technical. Their environment cannot distinguish the difference between performing entities. It is a structure which identifies minimum requirements that results in all entities being the same.
9. Professionals are identified by a minimum requirement of education, certification and experience. They include designers, architects, quantity surveyors, procurement managers and project managers.
10. Professionals will resist the change from a client centric to an expert vendor centric environment despite research tests identifying their decision making, management and control as the greatest source of risk.
11. Performance information increases transparency, accountability and performance.
12. Performance information are metrics used in communicating the capability of experts on specific projects.
13. The amount of performance information should be minimized to create transparency.
14. Performance information should be the responsibility of the expert vendor.
15. Communications in the supply chain should be minimized to the language of metrics that do not require decision making.

PBSRG is working with the first Alpha general contractor and service distributor using the same concepts of performance information. PBSRG also utilizes the BVA to compete vendors to identify the best value for any service. The greatest lesson learned is that one vendor can create competition by themselves by utilizing performance information and transparency. The number of visionaries who can see into the future, make things simple [transparency], and can tell the difference between options, in the industry is limited, and the identification and use of these expert services always results in the best value.

Recommendation

Further research is required using industry tests to identify examples of performance information that leads to transparency. The future of project management and risk management and the utilization of automation [reduction of human functions] is also recommended.

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The Impact of Utilizing Expertise to Project Risk and Performance

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Organizations have had difficulty in finding good project and risk management techniques that will deliver high performing projects. Research has identified common risks that occur on projects, but previous research has had difficulty coming up with reliable methods to mitigate those risks. However, the Best Value Approach (BVA) has proven to be effective in minimizing risk and increasing project performance. The crux of the BVA is the utilization of experts to minimize project risk. The BVA approach is unique from other project management methodologies which focus on increasing communication, collaboration and decision making. Previous research shows that client stakeholders are the cause of the majority of project risks, while the expert vendors usually do not cause risk on a project. It has been observed that expert vendors are able to minimize client stakeholder risk by transparent planning and tracking. Using case study research, an expert contractor's project is analyzed to determine the impact of using the BVA project management methodology to minimize project risk. As a result, the contractor did not cause any risk based on time and cost and helped the client minimize their risk. The research identifies eight risk mitigating actions the contractor applied through the BVA. The majority of the risk mitigating actions were performed primarily in the preparation and preplanning phases of the project.

Keywords: Expert, Expertise, Project Management, Project Performance, Best Value Approach, Procurement, Risk Mitigation, Risk Management.

Introduction

Organizations in multiple industries (such as information technology (IT), construction, health, aerospace, energy and manufacturing) have struggled to find project and risk management practices that have proven to deliver high performing projects (Rivera, 2017). According to a study by Rivera (2017), the average percent of construction and IT projects delivered on time is 20% and 40% respectively. Meanwhile, their percent of projects delivered on budget is 32% and 43% respectively. By analyzing project case studies, researchers have identified common risks including weather conditions, design changes, payment issues, shortages and additional work (Algahtany, 2018; Le, 2019). Methods to mitigate project risks have not led to a conclusive solution. There is a need in all industries to identify more efficient and consistent practices to mitigate risk and increase project performance.

The Best Value Approach and Risk Mitigation

The Best Value Approach (BVA) is a paradigm applied throughout the supply chain of a project (including procurement, planning and execution). The BVA has been shown to be effective in minimizing risk and increasing project performance (Duren & Doree, 2008; State of Hawaii Report 2002). Kashiwagi (2019) indicates that at the crux of the BVA is the utilization of experts to minimize risk and increase project performance. This means that the BVA aims to minimize management, communication, and collaboration by shifting full accountability and control of the project to the expert vendor. Rivera and Kashiwagi (2016b) analyzed 12 different project management methodologies (such as agile, lean, waterfall, and Prince2) and found that the idea of utilizing expertise to minimize risk and increase performance is unique to the BVA model. They identified that the majority of project and risk management models focus on increasing communication and collaboration to mitigate risk and increase performance. Ultimately, the BVA process is effective because each step facilitates the utilization of expertise. It has been proposed that the BVA is successful in mitigating risk because it makes the expert vendor accountable, because the expert is the only person with the capability to minimize risk. For over 20 years, the Performance Based Studies Research Group has researched the BVA and the expert's responsibility of risk mitigation and have identified the following (Rivera, 2014):

1. Experts have no risk in a project.
2. The greatest risk to a project is caused by nonexpert stakeholders.
3. Experts are able to minimize risk caused by nonexpert stakeholders through transparent planning and tracking.

These findings have been confirmed in two longitudinal studies with the US Army Medical Command (J. Kashiwagi, Sullivan & D. Kashiwagi, 2009; Kashiwagi, D., Kashiwagi, J., Smithwick, J., Kashiwagi, I., Kashiwagi, A., 2012;) and a Conglomerate of Minnesota government entities (Kashiwagi, 2012; Rivera & Kashiwagi, 2016a). The US Army Medical Command (MEDCOM) study identified that the vendor caused 0.0% cost deviation and 2.2% schedule deviation for 619 projects valuing $1.027 billion. The client, identified as the greatest source of risk, caused 4.13% cost deviation and 30.84% schedule deviation. The Minnesota study identified that the vendor caused 0.01% cost deviation and 2.65% schedule deviation for 399 projects valuing $438.88 million. The client was identified to have caused 7.61% cost deviation and 21.92% schedule deviation to the projects. Other case studies have confirmed similar findings, including:

1. $1 billion pilot project in the Netherlands for road widening (D. Kashiwagi & J. Kashiwagi, 2011; Van de Rijt, Witteveen, Vis & Santema, 2011) that identified the client to be the source of 99.5% of cost and 82.5% of time deviations.
2. A longitudinal study of a Dutch government agency Rijkswaterstaat (Van de Rijt, Witteveen, Vis & Santema, 2011; Witteveen & Van de Rijt, 2013) which identified in 80% of their quality procured projects the winning vendor was also the lowest cost. The study identified experts to deliver lower costs at higher value due to their capability to minimize risk and inefficiency.

3. A state government agency (Kashiwagi & Rivera, 2016) increased their project manager's work capacity by 22%, with vendor's completing 102% more work in 33% less time, through the utilization of an expert vendor's performance tracking system.
4. A public university (Kashiwagi, Savicky & Parmar, 2003) completed 11 roofing projects ($2.3 million) using the BVA process to utilize expertise. The projects were completed on time with 90% of projects ahead of time and 28% below budget. The study determined the high performance was due to the control over the projects given to the experts which allowed the experts to properly mitigate risk. In 56% of the projects, the vendor performed additional work at no charge and made higher profits than traditionally run projects.
5. The state of Hawaii (Kashiwagi & Savicky, 2003) completed 96 roofing projects using the BVA to utilize expertise. Through the use of expertise, the state was able to reduce projects costs by 13.8% compared to traditionally run projects which did not utilize the vendor's expertise. This was identified to be due to the mitigation of risks. The prime risks were reducing design errors from 11% to 2.5%.

The BVA research findings are not radical concepts. Expertise has already been linked to the improvement of risk management (Dreyfus & Dreyfus, 1980; Gobet, 2015). There are multiple factors which have been used to define experts and their level of expertise (Campitelli & Gobet, 2004; Epstein, 1996; Meehl, 1954). Common factors include experience, diplomas, and performance measurements specific to a domain. Gobet's (2015, p.12) definition of expertise is 'knowledge and skills', with an expert being defined as 'somebody who obtains results that are vastly superior to those obtained by the majority of the population'. This definition of an expert can be applied recursively to expertise, emphasizing both the individual's knowledge and the individual's skills. The application of this definition to skills is straightforward as the results of both an expert and nonexpert can be observed through project performance.

Gobet's (2015) research emphasizes that with any definition of an expert, perception is at the heart of expertise. He concludes "…experts literally 'see' things differently compared to novices". Dreyfus and Dreyfus (1980) established a standard five-stage model of mental activities (Dreyfus model) from novices to experts. The Dreyfus model addresses the change in perception and understanding of an expert which allows a situation to be seen less as a compilation of equally relevant bits and more as a complete whole in which only certain parts are relevant. Schoenfeld (1982) similarly identifies the difference in the perception between experts and novices to be rooted in their expertise. Benner's (1984) analysis of the Dreyfus model characterizes the expert's perception as the ability to see the overall picture and alternative approaches; the vision of what may be possible. As such, experts are identified to have an intuitive grasp of the situation. Klein and Hoffman (1992) identify that it is not just perceiving what is there but also perceiving what is not there. Benner (1984) notes that it is difficult to pass the expert's perception or mentality to others. Experts operate from a deep understanding of the situation which cannot be measured but can only be seen through their actions and outcomes.

Gobet, and other researchers in the field of expertise, have identified that the key to success lies with the expert. The only way to mitigate risk is through utilizing expertise. Applying this to the BVA model, it identifies that the BVA model should be a vendor centric approach and not a client centric approach, where the key to success and risk mitigation lies with the expert vendor using the model. However, most research tests focus on how the client uses the BVA model, and not the impact the BVA model has when used by an expert vendor.

Research Proposal

This research aims to document the impact the Best Value Approach (BVA) model can have when an expert vendor uses the model to minimize risk on a project, specifically within the construction industry. The research questions are as follows:

- What is the impact on project performance when an expert vendor utilizes the BVA?
- How does the BVA help a vendor minimize risk?

Case study research was used to answer the research question. The procedure followed includes:

1. Identification of an expert through the BVA process.
2. Documenting how the expert vendor used the BVA model.
3. Analyzing the impact of the expert vendor using the BVA model.

Case Study Documentation

Client Background and Requirement

The client was a government organization familiar with the Best Value Approach. They have used BVA as a method to procure construction work for their school district for years. The client in this case was looking for a vendor (contractor) for the renovation of a school's kitchen and indoor air quality system. The project consisted of:

1. Demolition and removal of heating, ventilation, air conditioning (HVAC) systems in classrooms, hallways, offices, gymnasium and associate mechanical spaces including roof top equipment.
2. Installation of air handling units (AHU), energy recovery units (ERU), classroom induction displacement air units and chilled beams in order to provide ventilation, heat and dehumidification.
3. Installation of central chiller plant and ice storage system.
4. Installation of complete direct digital controls (DDC) to HVAC, plumbing, electrical and associated low-voltage systems.
5. Remodeling of bathrooms and kitchen to code compliance.
6. Providing related demolition, electrical, patching, miscellaneous equipment. Other architectural features will be replaced such as carpeting and doors.

The client provided the contractor with a budget: $4,933,206 and all necessary construction documents including plans and specification.

Education and Schedule

The RFP was shared with contractors within the area. There were multiple contractors within the area which were experienced and familiar with the BVA as the client had delivered multiple BVA projects over the years. Due to the familiarity with the BVA, the client held one educational session (pre-proposal meeting) and allowed 14 calendar days for the contractors to prepare their proposals. In the RFP, the contractors were given the following schedule (see Table 1):

Table 1: Procurement Schedule

Schedule Activity	**Date**
RFP Released	1/28/2016
Pre-Proposal Meeting (MANDATORY FOR PRIME GENERAL CONTRACTORS)	2/2/2016
Last Day for Questions at 12:00 PM	2/5/2016
Proposals Due (10:00 AM CST Time) Risk Assessment / Value Enhancement due at 12:30 PM	2/11/2016
Interviews	2/12/2016
Identification of Potential Best-Value	2/15/2016
Clarification Kick Off Meeting (Tentative)	2/18/2016
Board Action	03/08/16 or prior
Project Award	03/09/16 or before
Start Construction Date	6/13/2016
Anticipated substantial completion date. The building must be ready for staff to clean, wax and move in. Work behind the scenes may continue.	8/19/2016
Final Completion	10/14/2016

Selection Phase

The client received two proposals from general contractors (Contractor A and Contractor B) both of whom utilized multiple subcontractors for critical components of the project such as electrical, mechanical, roofing. Each written submittal was evaluated, and the ratings identified a prioritized best value contractor. Three client committee members rated the contractor submittals and interviewed both contractors' project manager and site superintendent. The results are summarized in Table 2.

Table 2: Contractor Awarded Points and Prioritization

Average Raw Scores

Criteria (Raw)	Units	Contractor A	Contractor B
Level of Expertise rating	(1-10)	8.3	6.7
Risk Assessment rating	(1-10)	8.3	8.3
Value Added rating	(1-10)	8.3	8.3
References	Pass / Fail	Pass	Pass
Interview rating	(1-10)	10.0	9.2
Total Cost	$	$3,160,000	$3,340,696

Normalized Scores

Criteria (Normalized)	Best Score	Contractor A	Contractor B
Level of Expertise rating	8.3	1.00	0.80
Risk Assessment rating	8.3	1.00	1.00
Value Added rating	8.3	1.00	1.00
References	Pass	1.00	1.00
Interview rating	10.0	1.00	0.92
Total Cost	$3,160,000	1.00	0.95

Assigned Points and Prioritization

Criteria (Assigned Points)	Weight	Contractor A	Contractor B
Level of Expertise rating	20	20.0	16.0
Risk Assessment rating	20	20.0	20.0
Value Added rating	10	10.0	10.0
References	5	5.0	5.0
Interview rating	30	30.0	27.5
Total Cost	15	15	14.2
Total Points	100	100	92.7
Prioritization		1	2

The selection phase resulted in prioritizing Contractor A to move into the clarification phase. Contractor A's cost was 23.25% below the client's budget. They provided an expert project team based on the previous performance metrics including the project manager, superintendent, and electrical, mechanical and roofing subcontractors [see Table 3]. In comparison to their competitor, Contractor A matched or exceeded their competitors scores [see Table 2]. Additionally, Contractor A's total cost for the alternatives was 26% lower than their competitor [see Table 4]. The alternatives were not included in the base proposal cost but were optional add-ons of the client. Beyond their overall level of expertise, Contractor A demonstrated the capability to mitigate risk for the client through the identification of key risks (Risk Assessment) based on the client requirement. Lastly, the contractor provided potential value-added options which could improve the quality of the client's objective with options which could potentially minimize the cost to the client.

The major risks and value-added options were identified within the general, electrical and mechanical aspects of the project. Each risk and value-added option were supported by previous implementations. An example of a risk submitted by the contractor is as follows:

- General Risk – Scope of work changes due to building code, city plan review, and discrepancies in the bid documents due to unforeseen or existing conditions.

- Mitigation measure – The best value proposal includes only what was shown or easily understood from the bid documents. Each item that comes up will be resolved and a solution will be presented to the Owner within (5) days detailing schedule and cost impact to the project. If the Owner approves the time and cost impacts, we will generate the change order and proceed with the work. If the Owner objects, the time and cost impact will be tracked on the weekly risk report.
- Documented Performance – This process was utilized on 13 best value school indoor air quality projects with a total valuation of $37,386,000. The schedule delay rate was (-1%), design-initiated change order rate was (2.6%), contractor-initiated change order rate was (-2%) and our overall customer satisfaction rating was 99%.

Examples of other risk and value-added options the contractor included in their proposal were as follows:

1. Electrical Risk – The new electrical transformers are located inside the new mechanical enclosure which doesn't meet the local power company's standard based on their website.
2. Mechanical Risk – There is existing piping that will be reused on this project. Based on past experience, some of the existing will not hold a final pressure test to receive final approval from the building official.
3. General value-added option – Provide chain-link fence with plastic screening in lieu of the sound wall specified at the mechanical enclosure. It would provide cost savings to the owner without impacting the final appearance of enclosure. This process was utilized on three Best Value school indoor air quality projects with a total valuation of $5,415,000. The schedule delay rate was (-0.25%), design-initiated change order rate was (1.4%), contractor-initiated change order rate was (-3.5%) and our overall customer satisfaction rating was 98%.

Table 3: Alternative Costs Comparison

Alternate Costs	**Contractor A**	**Contractor B**	**Difference (A – B)**
Alternate #1 (Roof)	$425,500	$523,844	-$98,344
Alternate #2 (Concrete Floors)	$50,000	$73,142	-$23,142
Alternate #3 (Technology Cabinets)	$10,800	$13,594	-$2,794
Alternate #4 (Delete Ice Storage Modules)	-$80,000	-$79,096	-$904
Alternate #5 (Delete Fire Pump and Fire Pump room)	-$29,000	-$22,860	-$6,140
Total	$377,300	$508,624	-$131,324

Table 4: Level of Expertise of Contractor A's Team

Contractor Team (level of expertise)	**PM / Superintendent**	**Electrical**	**Mechanical**	**Roofing**
# of similar projects	2 (within last year)	7	10	1
Total cost	$ 7,140,000	$ 10,590,000	$ 13,439,000	$ 3,400,000
Average cost	$ 3,570,000	$ 1,512,857	$ 1,343,900	$ 3,400,000
Time deviation	-1%	-0.25%	-0.25%	-0.25%
Cost deviation (due to contractor)	0%	-1%	-1%	-1%
Client Satisfaction	98%	98%	98%	98%

Best Value Contractor's Perception and Usage of the BVA Model

Additional insights were gained by interviewing and discussing the project with the best value contractor. As a general contractor, they felt the BVA aligns best with their company's core values of ownership, integrity and teamwork. When they find a project that will be awarded using the BVA, there is no hesitation to pursue it. The bid manager responded that: '*The BVA gives us an opportunity to do what we do best, pre-plan a project from beginning to end and share that plan and its associated cost with the owner.*'

This project was the contractor's 12th awarded contract out of 16 BVA RFPs for this client over the course of 7 years. They were given 14 days to prepare and respond to the RFP. In this case after a review of the construction documents and other available project information the contractor knew they could align an expert project manager and superintendent to the project. Once the contractor's internal team was determined, they focused on finding trade partners to bring onboard. The contractor also used the methods of the BVA model to select their subcontractors for this project. Identifying their subcontractors based on their past performance and level of expertise. Looking at performance metrics to select the mechanical and electrical subcontractors (see Table 4). With the contractor's team in place they assigned a bid manager to the team.

The bid manager's tasks included:

1. Assign tasks to team members.
2. Coordinate plans and schedule creation with the project manager, superintendent, and partner sub-contractors.
3. Receive and review documentation and assemble relevant performance metrics for the contractor's plan ideas.
4. Coordinate scope review with partner sub-contractors and contractor's team
5. Receive and review all sub-contractor bid.
6. Submit official response to the owner.

In a traditional low bid environment, the contractor normally waits until the last minute for the lowest bid and scrambles to make sure that their bid is complete at the deadline. When following the BVA, the contractor focuses on selecting a proven team of expert contractors in key areas to help build the proposal, the building envelope, mechanical and electrical sub-contractors. The contractor then meets as a team prior to the proposal due date. All team members understand everyone's price, schedule, "plans", potential risks and impact of those risks if they occur, and documented performance. The goal for the contractor is to have the assigned project manager do minimal work to run a successful project. The leg work is done while preparing the response.

During the preparation of the proposal the contractor did risk mitigating actions such as:

1. Identifying unique aspects of the project requirement including: the mechanical equipment yard being located directly adjacent to the playground, requiring a non-climbable enclosure; and shallow bed rock that made the excavations challenging.
2. Asking questions of the owner and design team to clarify unknowns.
3. Coordinating schedules and expectations internally to ensure optimized pricing and scoping. For example, during the development of their plan for the project the contractor realized that the polishing of the concrete floors would need to be done on the second shift for their plan to go well. This was necessary because the corridors and other spaces also had extensive mechanical and electrical work above the ceiling. To mitigate this risk, the contractor directed the polished concrete subcontractors, prior to bid, that they were expected to work 3:00pm – 10:00pm (second shift) so that their operations would not be in the way of the overhead work being done in the same area. Without this pre-bid communication, multiple contractors would show up to the project trying to work in the same space at the same time. Such a work atmosphere would lead to confusion, finger pointing, re-mobilization charges from some of those contractors and additional labor charges when they are directed to work second shift. In addition to the cost impacts, the hours it takes to resolve the issues are wasted, and in a project where it must be delivered in 10 weeks, every minute matters. Often days are planned down to 15-minute increments to get everything done on time.

Clarification (Planning) Phase

Once Contractor A received notification that they were moving into the clarification phase, they immediately began preparations and coordination. The contractor was familiar with the BVA and the purpose and process of the clarification phase which is intended as a planning stage in the project. Using a contractor generated checklist for clarification phase deliverables (see Figure 1), they set a clarification phase schedule identifying responsibilities of both client and contractor (see Figure 2).

Preparations & Kickoff Meeting

☒	Identified vendor is notified
☒	Vendor Prepares Kickoff Meeting Materials
☒	Kick Off Meeting is scheduled
☒	Financial Summary is prepared
☒	Project Milestone Schedule is proposed
☒	First draft Risk Management Plan is proposed to address major risks and client concerns
☒	First draft Value Added Plan is proposed to clarify options for project
☒	Clarification Phase Schedule is proposed (including Client and Vendor tasks)
☒	Kick Off Meeting Is Held
☒	Clarification Phase Schedule is finalized and agreed to by Vendor & Client (at a minimum,

Figure 1: Clarification Phase Checklist

No	Clarification Phase Activity / Task	Party Responsible	Start Date	End Date
1	Clarification Phase Kick Off Meeting #1	All	2/18/16	2/18/16
2	A/E Review Value Add / Risks	Client (C), Designer (D), Contractor (V)	2/4/15	2/9/15
3	Clarification Phase Meeting #2	All	3/3/16	3/3/16
4	A/E and Owner Decisions on Value Add / Risks	C / D / V	2/11/15	2/16/15
9	School Board Approval	C	3/8/16	3/8/16
10	Project Award	C / D / V	3/23/16	3/23/16
11	Final Clarification Phase Meeting	C / D / V	3/23/16	3/23/16
12	Project Award / Notice to Proceed	C	3/23/16	3/23/16

Figure 2: Clarification Phase Schedule

Contractor A prepared the following documents within the clarification phase:

1. Milestone Plan with designated roles for each milestone.
2. Detailed Plan.
3. Assumptions, expectations, and roles/responsibilities.
4. Risk Management Plan.
5. Value added options.
6. Financial project summary (inclusive of scope changes).
7. Contract.

Key Points to the Contractor's Plan

The best value contractor identified a few points which were key in delivering a successful project due to the clarification phase. During this phase, the contractor's detailed plan was shared with the owner. By allowing the owner to see a simple and clear plan it allowed the owner to give feedback and questions before the project started, which normally would occur after the project started. Due to the upfront clarification and planning, adjustments could be made to the contractor's proposal with little to no deviations. In this case, all the owner's feedback was responded to in four weeks. None of the owner's requests had any impact to the contractor's overall plan.

In receiving the client's feedback, an issue with traditional plans is that they do not include the expectations or action items of stakeholders involved in the project. Traditional plans only include the action items of the contractor performing the work. The contractor identified the client stakeholders as the greatest risk to the project and as such identified within their schedule (detailed and milestone) the list of all actions required for successful implementation and the party responsible for each action (see Figure 2). In identifying the contractor's expectations of the client stakeholders, it allowed for proper clarification and feedback from the client to address potential risks or needed adjustments upfront rather than being surprised during the project.

An additional key part of the contractor's plan is that during the clarification phase the contractor laid out their plan for dealing with unforeseen conditions. The bid manager noted that: *"…there is always things hidden in walls, above ceilings or under floors when working in existing builds* *built in the 60s. Our detailed plan lays out who is required to do what within a given time frame. When an unforeseen issue arises, the plan goes into effect. Each person knows what to do, how long they have to do it and when it's complete. On a time-sensitive project like this every minute matters. The automated response eliminates the time to 'figure out what to do' so that we can focus on getting it done."*

The contractor provided a detailed plan to handle such risks. The risk mitigation plan identified the probability a risk would occur, description, plan to minimize risk from occurring, action if the risk occurred and projected impact (see Figure 3). Without this level of planning and risk mitigation, unforeseen conditions and owner requested changes could have added twice as many days and much more cost than they did. By preplanning and agreeing to procedures beforehand the contractor minimized the amount of waste caused by the traditional increase in communication and coordination.

Identified Risk 1: Risk Probability 90%	Scope of work changes due to building code, city plan review and discrepancies in the bid documents due to unforeseen or existing conditions.
Risk Description:	Each item that comes up will be resolved and a solution will be presented to the Owner within (5) days detailing schedule and cost impact to the project
Plan to Minimize Risk from Occurring:	• On a weekly basis Contractor will submit a Weekly Risk Report notifying the project team of any potential time or cost deviation while reviewing the Risk Management Plan on a weekly basis. • In our contracts to our subcontractors we require each subcontractor to submit a Weekly Risk Report every week so we are continually notified of potential risks. These basic steps will prevent potential risks from beginning major issues and creating time and cost deviations.
Action If the Risk Occurs	Once an item is encountered we will immediately notify all parties in writing on the day of the discovery of the potential time and cost impact. We will present to the owner and engineer the best solution that minimizes the time and cost impact to the project. If the owner approves the time and cost impacts, no action is required and we will generate the change order and proceed with the work. If the owner objects to the time and cost impact, we will not proceed with the work until directed in writing, and the time and cost impacts will be tracked on the weekly risk report.
Projected Impact (If Risk Occurs):	The time and cost impact will be addressed on a case-by-case basis.

Figure 3: Example Risk Mitigation Plan

Execution Phase

Due to the upfront planning, the contractor initiated their plan without promptings from the owner. Long lead time products were ordered, and everything was being put into place to prepare to start work on site on June 13, 2016. The contractor's crews mobilized to the site and things worked well. During the project, unforeseen conditions added 57 days and $129,808 to the project. Due to the pre-planning of the contractor to deal with these items as they came up, the impact to the cost and schedule were minimized.

For example, near the end of the project the owner came to the contractor with a request. The owner surprised the contractor with a special event in early August. The special event would require the contractor to focus their efforts in one section of the school so the rooms could be used for the event. This altered the initial plan and added cost for the overtime to recover the schedule deviation. Additionally, the owner had many other requests for additional scope of work to be added to the project. The additional work added 17 days and $56,446 to the project.

Throughout the duration of the project the contractor utilized the weekly risk report (WRR) tool provided through the BVA process. The WRR was used to coordinate and communicate the status of the project in terms of the schedule, potential risk, deviations to the project schedule / cost, and project performance. The WRR was an ongoing document which was sent to all major stakeholders allowing the client and contractor to continually have the same perception of the project status and upcoming actions necessary, with minimal communication.

Case Study Results

Contractor A was able to complete the original project scope on time in terms of the substantial completion and owner move-in dates. The project was extended (delayed) 74 days due to additional work the client requested which could not be completed until Christmas break, due to the school year. The project ended overbudget at a final cost of $4,002,549 due to unforeseen site conditions, design errors and client requests. The customer satisfaction on the project was given a 10 out of 10 overall rating (see Table 5 for full client ratings). It is identified that the schedule delay and increased cost was not due to the contractor (see Figure 4). In reviewing the project, the contractor bid manager noted that: *"This project for them proved once again that the owner is their biggest risk. However, with sufficient preplanning and coordination even unforeseen or client generated risks could be minimized and at times eliminated."*

Budget	
Initial Allocated Budget	$3,786,043.00
Current Estimated Budget	**$4,002,592.00**
$ Over Budget	**$216,549.00**
$ Due to Designer	$30,631.00
$ Due to Client	$56,446.00
$ Due to Contractor	-$336.00
$ Due to Unforeseen	$129,808.00
% Over Budget	**5.72%**
% Due to Designer	0.81%
% Due to Client	1.49%
% Due to Contractor	-0.01%
% Due to Unforeseen	3.43%

Schedule	
Initial Start Date	6/13/16
Initial Completion Date	10/14/16
Current Completion Date	**12/27/16**
Days Delayed	**74**
Days Due to Designer	0
Days Due to Client	17
Days Due to Contractor	0
Days Due to Unforeseen	57
% Over Schedule	**60.16%**
% Due to Designer	0.00%
% Due to Client	13.82%
% Due to Contractor	0.00%
% Due to Unforeseen	46.34%

Figure 4: Final Project Performance

Table 5: Client Close Out Performance Survey

#	**VENDOR PERFORMANCE EVALUATION CRITERIA** [10 represents that you were exceptionally satisfied, 5 that you were unsure/don't know and 1 represents that you were unsatisfied]	**UNIT**	**Rating**
1	Ability to manage the project cost (minimize change orders).	(1-10)	10
2	Ability to maintain project schedule (complete on-time or early).	(1-10)	10
3	Quality of workmanship.	(1-10)	10
4	Professionalism and ability to manage risks on project.	(1-10)	10
5	Ability to follow the user's rules, regulations, and requirements.	(1-10)	10
6	Vendor discussed alternative actions and explained why the selected process/monitoring/alternative represents the best value to the client.	(1-10)	10
7	Vendor has prepared the SOW so that risks are minimized.	(1-10)	10
8	Vendor provided a clear explanation and understanding of how all activities support achievement of client's objectives on the project.	(1-10)	10
9	Vendor's project deliverables (reports, actions, or key milestones) are delivered on planned schedule; if schedule deviations occurred, they were fully justified.	(1-10)	10
10	Weekly Progress Report is clear, concise, timely, and easy for client to understand.	(1-10)	10
11	Overall satisfaction and comfort level in hiring the vendor again.	(1-10)	10

The testing of the BVA resulted in a selection time of 14 calendar days (88 days if you include the clarification/planning phase) with a savings of $1.15M (23.25%) which includes added alternatives. Identifying and utilizing a contractor that also utilized the BVA model, who preplanned, performed risk mitigation and was able to deliver the project on time. The contractor was not responsible for any of the project time or cost deviations (see Table 6). The expert contractor was identified to apply the BVA model with the following eight key actions which reduced or eliminated project risk. These BVA actions summarized in Table 7 were shown to assist in reducing project risk and achieving the project performance results.

Table 6: Vendor Performance

Selection Phase Performance	**Results**
Time to procure [including clarification/planning phase]	14 days [88 days]
Budget / Awarded Cost	4,933,206 / $3,786,043
Procured Under budget	-23.25%
Project delivered on time (excluding additional work)	yes
Percent time and cost project deviation due to contractor	0%

Table 7: BVA Risk Mitigating Actions of Contractor

#	**Risk Mitigating Actions**
1	Contractor identification of expert personnel on team pre-submittal.
2	Internal coordination of expertise to eliminate any contractor risk pre-submittal.
3	Upfront use of the lead expert in the planning phase and using less expertise during execution.
4	Creation of plan inclusive of project risks outside of contractor control.
5	Contractor led project planning and coordination. Development of a non-technical simple plan that all stakeholders could understand.
6	Clarification of plan upfront with client stakeholders before project initiation regarding project roles and expected contribution to the project plan.
7	Setting agreed expectations and mitigating actions upfront which would minimize communication during the project.
8	Tracking of a non-technical project plan and reporting deviations through the Weekly Risk Report (WRR) and project performance metrics (time and cost).

Discussion and Findings

This research identified that an expert contractor that utilizes the BVA model may have the capability to eliminate all project deviation (risk) caused by the vendor. Results demonstrated that the expert saved time and money for the client. In terms of risk caused by other stakeholders (designer and client) and unforeseen events, the expert vendor was able to minimize their impact to the project, but not able to eliminate the impact to the project. Isaac Kashiwagi (2019) determined a potential reason for this gap can be caused by certain risk ultimately being outside the control of the expert.

When analyzing the type of risk mitigating actions of the expert, it was determined that the expert's actions were centered on identifying internal expertise and the use of that expertise throughout the project. Seven of the eight mitigating actions were performed during the preparation and planning process, before the project entered execution. The expert vendor was able to leverage their internal expertise upfront through planning and coordination of their plan with client stakeholders. During execution, the highlighted risk mitigating action was the Weekly Risk Report (WRR) that was able to accurately track deviations to the initial project plan.

The test differed from other examinations of experts as the BVA process used to classify an expert was not based on their years' experience or perceived skill but their actual past project performance. This definition as noted by Gobet (2015), may be the most accurate indication of an expert. The highlighted risk mitigating actions may differ based on the distinction of expertise. Future tests should be conducted to enlarge the list of risk mitigating actions of an expert using the same definition and indicating factors.

Conclusion

The construction industry has had a difficult time finding a model that can effectively minimize risk on a project and increase the project performance. The Best Value Approach (BVA) is one of the only delivery models that has had repeated testing documenting that it can mitigate risks that occur on projects and improve performance. The BVA model differs from other models because it focuses on mitigating risk through utilizing expertise and not management, communication, and collaboration. This makes the BVA model a vendor centric model instead of an owner centric model. It is a key difference between the BVA delivery method and other models being used in the industry. However, there have been very few research tests performed documenting a vendor utilizing the BVA model.

This paper performed a case study research documenting the impact of a vendor utilizing the BVA model on risk mitigation and project performance. The result of the research identified the following:

1. A vendor following the BVA model will select their subcontractors and team based on expertise and performance metrics.
2. A vendor following the BVA model will perform most of its risk mitigating actions before a project begins.

3. To mitigate the majority of risks a non-technical plan is required before a project begins and needs to be coordinated with all stakeholders.
4. A Weekly Risk Report (WRR) ensures that all stakeholders are satisfied and aware of the status of the project. It minimizes disputes and issues.
5. A vendor following the BVA model is able to increase performance and minimize the impact of all risks, regardless of if a stakeholder causes it.

The BVA delivery system is a vendor centric model. A vendor that adheres to its principles and follows its steps, has the ability to mitigate risk and increase performance. It is suggested that more case study research be performed to verify these results.

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Success Factors for Project Risk Management in Construction Projects: A Vietnam Case Study

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Despite being one of the oldest industries in human history, the modern construction industry is still suffering from delays, cost overruns, and low satisfaction levels. As construction activities greatly contribute to economic growth for any nation, the study of how to achieve success in construction projects should be continuously developing and attracting scholars' attention. The Vietnam Construction Industry (VCI) is no exception. The economy in Vietnam has been growing fast and steady with significant contributions from construction activities. The VCI also faces unique risks pertaining to the conditions of developing countries that require a separate study on project risk management strategies. This paper focuses on a survey that is adopted from 23 Critical Success Factors (CSFs) pertaining to common construction risks in the VCI. Factors were found through extensive literature reviews, and inputs were solicited from 101 VCI participants. The participants ranked those CSFs with respect to impact to project success. The study reveals the top five impactful CSFs such as all project parties clearly understand their responsibilities, more serious consideration during contractor selection stage, test contractors' experience and competency through successful projects in the past, project team members need to be well matched to particular projects, and promote pre-qualification of tenders and selective bidding. Spearman's rank-order correlation tests determined no significant differences between the participating groups. Factor analysis was conducted to explore the principal success factor groupings and yielded four outcomes – Improving Management Capability, Adequate Pre-Planning, Stakeholders' Management, and Performance-based Procurement. The findings lay the foundation to understand project management in developing countries and assist project managers in planning and forming strategies to ensure high performance in their projects.

Keywords: Construction Industry Risks, Risk Management, Project Management, Developing Countries, Critical Success Factors, Relative Importance Index, Factor Analysis, Vietnam

Introduction

The construction industry is one of the most important industries to the economy of any nation. It contributes to the economic growth, delivers jobs and provides critical infrastructure (e.g. healthcare facilities and transportation network) to support the growth and development of various economic sectors. While the construction industry is one of the oldest industries in any civilization, the modern construction industry (even the ones in the developed countries) is still marred with risks that results in project schedule delays, budget overruns, and low quality (Rivera et al., 2017). Hence, the study of how to achieve success in a construction project has never stopped developing and has continuously attracted scholars.

Once regarded as an economic disaster, Vietnam is now emerging as the latest East Asian growth engine which attracts the attention of global investors. Today, Vietnam is currently among the countries with the highest gross domestic product (GDP) growth rates. In 2002, GDP growth in Vietnam hit 7% (high) and recorded the fastest economic growth in Southeast Asia. In 2007, the GDP kept growing to 8.5%, marking the third consecutive year above the 8% benchmark for this small country (Ling & Bui, 2010; Long et al., 2004). That was an all-time high record in terms of growth rate, placing Vietnam second only to China in the Asia region. In 2009, Vietnam was one of the only South East Asian emerging economies not to have gone into a recession during the 2008 U.S. financial crisis. Since 2013, GDP growth has been recovering and increasing above 6% on average until now. In comparison, the U.S. GDP growth has been 3.2% on average in the past 10 years.

The construction sector accounts for the significant economic growth in Vietnam. The Vietnam Construction Industry (VCI) has been growing at 15% annually for the past 10 years. In 2002, VCI comprised 39% of the GDP growth rate. In 2011, VCI increased its contribution to 41.1%. Thanks to the promotion of industrialization from the Vietnamese government and infusing of foreign investments through the Official Development Assistance (ODA) program, construction growth rate has been healthy and consistent over the years (Nguyen Duy et al., 2004; Khanh & Kim, 2014; Luu et al., 2008). However, despite large growth and increasing demand for construction, multiple research efforts in the past 15 years, with the most recent one conducted by Le et al. (2019), have identified that there are still risks existing in the VCI that hinder performance. It is therefore imperative to develop and conduct research on risk management solutions for common risks in Vietnam. Particular attention is given to the development of factor models for enhancing the VCI project performance, and potentially construction industries in other developing countries.

Objectives of the Study

The main research objective is to identify success factors that could address common risks and improve project performance in the VCI. The research first identified the success factors through extensive literature review for developing countries, and prior research in the field. After which, the research team determined how different construction stakeholders rank the success factors, and how they perceive their impacts. The analysis finally identifies and models the potential relationships between those factors. The results are simplified factors that can be used to improve project management capability in the VCI. Other countries that face similar construction risks as Vietnam may also find the results useful.

Literature Review

Despite different perceptions of success among project participants, construction projects are widely acknowledged as successful when it is delivered on time, within budget, in accordance with specifications and to stakeholders' satisfaction (Sanvido et al., 1992). Critical Success Factors (CSFs) are certain conditions when achieved would lead to such success, defined by Rockart (1982) as: 'those few key areas of activity in which favorable results are absolutely necessary for a manager to reach his/her goals'. The CSF methodology attempts to identify the key areas that are essential for management success and has been utilized in financial services, information systems, manufacturing industry, and construction management (Li et al., 2005). Other functions of CSFs include: to guide an organization in strategic plans development, to form strategies, to identify critical issues and risks associated with a plan, and to help achieve high performance (Nguyen Duy et al., 2004).

In 2019, Le et al. revealed twenty-three common risk factors in developing countries and conducted a case study about their relative impacts in Vietnam. To develop an effective framework to manage those risks, the authors attempt to identify CSFs pertaining to them. The following CSFs have been found through extensive literature reviews and case analysis from published journals:

- CSFs related to procurement practices: more serious consideration during contractor selection stage (Le-Hoai et al., 2008; Koushki et al., 2007; Toor & Ogunlana, 2010), promote pre-qualification of tenders and selective bidding (Long et al., 2004), change tender selection philosophy from "lowest-price wins" to select the most responsive contractor based on preset criteria (Luu et al., 2009, Sambasivan & Soon, 2007, Lo et al., 2006), test contractors' experience and competency through successful projects in the past (Le-Hoai et al., 2008, Sambasivan & Soon, 2007), select designer based on experience and past performance (Thuyet et al., 2007, Yakubu & Sun, 2010), simplify bidding process (Thuyet et al., 2007), save time and cost during the bidding process (Long et al., 2004), and improve contracts to equitably allocate risks between parties (Le-Hoai et al., 2008, Faridi & El-Sayegh, 2006, Sambasivan & Soon, 2007).
- CSFs related to performance assessment: measurable projects performance (Khanh & Kim, 2014, Frimpong et al., 2003), create practical models to assess the changes of schedule and cost (Le-Hoai et al., 2008; Lo et al., 2006; Yakubu & Sun, 2010; Toor & Ogunlana, 2010), and measurable construction company's performance for improvement (Luu et al., 2008, Lo et al., 2006).
- CSFs related to management: introduce effective construction management (Long et al., 2004; Lo et al., 2006; Faridi & El-Sayegh, 2006; Frimpong et al., 2003; Yakubu & Sun, 2010), all project parties clearly understand their responsibilities (Khanh & Kim, 2014; Koushki et al., 2007; Lo et al., 2006; Faridi & El-Sayegh, 2006; Frimpong et al., 2003; Yakubu & Sun, 2010), project team members need to be well matched to particular projects (Thuyet et al., 2007), and adequate resources invested in the pre-construction phase (Lo et al., 2006, Sambasivan & Soon, 2007).
- CSFs related to other high impact issues: have a plan to assist inexperienced owners (Thuyet et al., 2007), effective communication between owner and designer (Thuyet et al., 2007), select high performing consultants to evaluate design works (Thuyet et al., 2007; Koushki et al., 2007), owners understand their responsibility for timely payment to contractors (Le-Hoai et al., 2008; Sambasivan & Soon, 2007), all project parties, especially contractors, understand their responsibility to provide materials on time (Le-Hoai et al., 2008; Sambasivan & Soon, 2007; Yakubu & Sun, 2010), good relationships with both central and local governments (Thuyet et al., 2007), projects are inspected by government officials (Ling & Bui, 2010, Faridi & El-Sayegh, 2006), and foreign experts are involved (Ling & Bui, 2010).

While these CSFs were identified, their relative importance to one another has yet been determined. They could all be considered important, but some could have higher impact to success than others. Hence, it is prudent to attempt ranking them in terms of impact to project performance and attention should be given to them during project development. Additionally, the interrelationships among the CSFs should be revealed so the findings of this study could be readily and consistently applied for future projects (Nguyen Duy et al., 2004).

Research Methodology

This research uses a field survey as its key research method to collect data pertaining to the research objectives. The survey collects data from various construction stakeholders pertaining to the application of various strategies and practices that impact construction performances, particularly, time, cost overrun and client satisfaction. The survey was designed using the 23 CSFs identified from the literature. The survey also aimed to identify the relative impact that those CSFs had on construction project performance. The five-point Likert scale of 0 to 4 measured the respondents' perception of the impact each CSF has on projects success. The numerical values assigned for the Likert Scale are as follow: '0 – No Impact, 1 – Mild, 2 – Moderate, 3 – Very, 4 – Extremely'. The respondents had the option to include additional CSF they personally pursued but was not included in the initial 23 CSFs.

The survey was validated before it was distributed. Four (4) construction industry experts were identified and participated in the validation exercises. The experts included a civil engineering/construction engineering professor, a practicing contractor, and two owner representatives. These experts had at least 15 years of experience in the industry at the time of the validation test. The experts were requested to critically review the structure and content of the questionnaire, and recommended changes to the originals. Their recommendations are incorporated into the final questionnaire which was then sent to the selected survey participants in Vietnam. The participants are divided into "Owners", "Contractors" and "Consultants", and they were either sent an email with a link connected to the survey or physical mail to their offices. The online survey was developed using Google Survey and printed copies of the survey forms were mailed out with return envelopes enclosed. Completed surveys were compiled online and physically from the returned mails. The surveys were returned within a month after they were mailed out.

The collected surveys were quantitatively analyzed using IBM SPSS Statistics v25. The research team employed the following techniques:

1. Cronbach's alpha coefficients to test internal consistency of the results.
2. Relative Importance Indexing to rank the CSFs based on response ratings data.
3. Spearman's rank-order correlation coefficient to determine the degree of agreement of rankings between each responded group.
4. Factor analysis to derive interrelationships among the CSFs.

Data Collection

The survey was sent to over 300 construction professionals from three stakeholder groups in Vietnam. These professionals were selected from companies that faced the highest risk factors, such as the type, complexity and size of the construction projects. These companies were involved to determine their perspectives in managing those risks. The research team avoided companies that were involved in low-risk projects, such as renovation and structural repairs where cost and budget are less volatile, and project risk management practices are standard and straightforward.

Nearly half of the surveys were returned (140). Of the 140 surveys that were returned, incomplete surveys were eliminated from the responses. Thirty-nine (39) surveys were removed from the analysis as a result. A total of 101 completed surveys remained for further analysis (described in Table 1). While the total response rate was around 47%, a total of 33.7% of the invited surveys were used for the analysis.

Table 1: Project Complexity Factors

Demographic Characteristics	Responses	%
Groups		
Owners	44	43.6%
Contractors	35	34.7%
Consultants	22	21.8%
Industry Experience		
0 - 5 years	18	17.8%
6 - 10 years	17	16.8%
11 - 20 years	41	40.6%
Over 20 years	25	24.8%
Project Types		
Commercial / Residential	62	61.4%
Infrastructure / Heavy Civil	21	20.8%
Industrial	18	17.8%
Project Sizes		
< $1M	22	21.8%
$1M - 5M	45	44.6%
> $5M	34	33.7%

Among the 101 returned surveys, 44 respondents worked for owners (43.6% of the responses), 35 for contractors (34.7%), and 22 for designers and/or consultants (21.8%). The majority of participants held high level managerial positions, such as project managers, directors or associate directors. The respondents' mean years of relevant experience in the construction industry is around 16 years. The experienced profiles and the management roles of the respondents would likely translate into reliable results and thus enhance the quality of the findings. The participants did not make any significant contributions of new CSFs to the survey and concluded that the initial 23 CSFs generally describe their risk management approach to success.

Data Analysis

The research team used the following techniques:

1. Cronbach's alpha coefficients to test internal consistency of the results.
2. Relative Importance Indexing to rank the CSFs based on response ratings data.
3. Spearman's rank-order correlation coefficient to determine the degree of agreement of rankings between each responded group.
4. Factor analysis to derive interrelationships among the CSFs.

These are described in the following subsections, and the analysis will follow.

Cronbach's Alpha Coefficients

The Cronbach's Alpha Coefficients of the internal consistency reliability tests for impact ratings of the survey results are 0.940. Litwin & Fink (1995) suggested that consistency is high when Cronbach's alpha is above 0.7. This confirmed that there is high internal consistency among the answers.

Relative Importance Indexing

The survey results were analyzed using Relative Importance Index previously used in several studies (Kaming et al., 1997; Le-Hoai, 2008; Doloi, et al., 2012). This index measures the impact of each CSF to project performance. It is computed with the following formula:

$$RII = \frac{\sum_0^4 a_i n_i}{4N}$$

a = the weight assigned to each response (as in this research, a range of 0 for "No Impact" to 4 for "Extremely"), n = frequency of occurrence for each response, and N = total number of responses.

Ranking and Analysis of CSFs

The calculations of RII and the rankings of the twenty-three (23) CSFs identified in the questionnaire are presented in Table 2 which shows overall that 10 factors scored RII values higher than 0.7, 10 factors scored RII values between 0.6 and 0.5, and three factors scored RII values between 0.5 and 0.4. Each CSFs are then further investigated:

The first ranked CSF emphasizes that 'All project parties clearly understand their responsibilities' (Table 2: RII value 0.745; ranked first overall). This suggests that project stakeholders should be aware of what they are responsible for at all times to ensure timely actions and quality results. This applies to contracted parties such as contractors, suppliers, and consultants, as well as (but not limited to) owners for timely approvals and payments, and local government for permit approvals and inspections. The best time to achieve this CSF is before the project starts. Kashiwagi (2019) recommends a clarification period between contractor selection and project execution for this purpose. During clarification period, contractors will present their plans from beginning to end to all stakeholders along with expected responsibilities for each party. The contractors will also estimate the time and cost deviations to projects whenever a party fails to meet their responsibilities. The stakeholders will then provide feedback to adjust and finalize the plan before it becomes part of the contract. Such practices allow all project parties to understand their roles and responsibilities at the beginning to act and cooperate accordingly as the project develops.

'More serious consideration during contractor selection stage' is considered the second most important CSF (Table 2: RII value 0.738; ranked second overall). Vietnam and other developing countries have been criticized for having inefficient bidding and low-bid practices. Selected contractors are often unable to deliver projects on-time and within budget. An innovative, strategic and proven tendering approach is therefore critical to ensure project success.

One way to improve tendering quality is to 'Test contractors' experience and competency through successful projects in the past' (Table 2: RII value 0.735; ranked third overall). A contractor with inadequate experience is likely incapable to plan and manage projects properly, and that could lead to disastrous consequences (Sambasivan & Soon, 2007). As Vietnam is still in development, contracting and consultancy firms have been mushrooming the industry on a daily basis, but quantity does not always mean quality (Le-Hoai et al., 2008). Therefore, experience and success in past projects should be considered in selecting contractors.

Workers that will be working on projects should also be tested to confirm that 'Project team members need to be well matched to particular projects' (Table 2: RII value 0.735; ranked fourth overall). Competent project managers and competent project teams hold vital roles in successful projects; however, the quantity and quality of such human resources are still very scarce in Vietnam and probably other developing countries (Le-Hoai et al., 2008). In order to win a project, companies may present their best teams while bidding but assign the project to less experienced groups after receiving the contract. Owners should request profiles of project team members and their time involvement during the project as part of the bidding submission. Those documents will be compared with project requirements to ensure that team members are qualified and capable to successfully deliver projects.

'Promote pre-qualification of tenders and selective bidding' is another important CSF (Table 2: RII value 0.728; ranked fifth overall). In general, this term means that the owner is inviting short-listed contractors to bid on the project. This practice is an alternative to open competitive bidding and sometimes proves to save time and cost for the owner (Long et al., 2004). Since inexperienced owners do not have enough expertise to shortlist the contractors by themselves, they should consult an expert before considering selective bidding. Nevertheless, this practice has yet been taken full advantage of by Vietnamese owners (Long et al., 2004).

Similar to selecting contractors, owners should consider to 'Select designer based on experience and past performance' (Table 2 RII value 0.728; ranked sixth overall). Le et al. (2019) observed that domestic and foreign design firms in Vietnam had been encountering design issues that led to change orders and inaccurate estimates throughout projects. Possible causes of those design issues are the owners' lack of experience and uncertainty in what they want. Those risks could be minimized and mitigated by an experienced designer with proven past performance.

Other CSFs pertaining to design are 'Select high performing consultants to evaluate design works' (Table 2: RII value 0.703; ranked tenth overall) and 'Effective communication between owner and designer' (Table 2: RII value 0.662; ranked fourteenth overall). As design issues often surface much later after the design is completed and bid out, changes to design could be costly, reduce project's profits, and increase time. Having a third party to evaluate design works to identify design flaws early on could save cost and time from design-related headache arising later (Le-Hoai et al., 2008). Having competent consultants to evaluate design works also ensure constructability, accurate translation of owner's ideas to design parties, and effective concurrent engineering (Thuyet et al., 2007).

By nature, materials are crucial for construction success. Hence, it is essential that 'All project parties, especially contractors, understand their responsibility to provide materials on time' (Table 2: RII value 0.725; ranked seventh overall). Due to fast development and high demands, material prices in Vietnam and other developing countries often fluctuate (Le-Hoai et al., 2008; Sambasivan & Soon, 2007). Additionally, scarcity of specialized, long-lead items, interest and inflation rates, and inaccurate estimates are common risks that cause delay in supplying materials (Le et al., 2019). Depends on project nature and material requirements, responsible parties should consider additional planning and surveying, and development of strategies upfront to ensure timely delivery of materials (Le-Hoai et al., 2008).

It is important that 'Owners understand their responsibility for timely payment to contractors' (Table 2: RII value 0.718; ranked eighth overall). Money ensures construction projects run smoothly and is an obvious imperative to carry out projects (Long et al., 2004). Owners' financial capability in Vietnam is not strong. Most private owners are mid-sized developers who often struggle with land use compensation and payments to contractors (Luu et al., 2009), while on the other hand, public owners are mandated to follow excessive bureaucratic procedures that take a long time to approve completed works for payments. Hence, additional efforts are required for owners understand and manage the risks on late payments.

'Change tender selection philosophy from 'lowest price wins' to select the most responsive contractor based on preset criteria' in the procurement process is necessary to achieve success (Table 2: RII value 0.710; ranked ninth overall). Construction projects, especially the complex ones, are not commodities that can be procured by just a cost factor. Contract awarding to the lowest bidder has been criticized in the VCI as it attracts contractors with inadequate experience that may bring unfavorable consequences such as sub-standard work, change orders, and bankruptcy that make low-bid projects end up with high overall costs (Luu et al., 2009; Sambasivan & Soon, 2007; Lo et al., 2006). Hence, the practice of selecting the lowest bidder needs to change, especially for public owners who tend to select the lowest bidders to justify with the citizens.

'Adequate resources invested in the pre-construction phase' (Table 2: RII value 0.693; ranked eleventh overall) is also important. The Cost of Change curve demonstrates that the longer a flaw is left unaddressed during a project, the more expensive it will be to fix (Griffiths, 2015). This concept applies to design flaws as mentioned earlier as well as other dominant risks in the VCI such as lack of site (soil, weather, traffic) and legal information (Le et al., 2019). Those risks are important input data for project activities and could be addressed with adequate time and budget built into the master program to investigate their conditions during pre-construction phase (Ling & Bui, 2010).

‘Have a plan to assist inexperienced owners’ (Table 2: RII value 0.691; ranked twelfth overall) is important but often overlooked as shown by relatively lower rankings from all parties. Despite not directly performing the works, the owner is revealed as the party that would often cause risks and deviations in a construction project (Elawi et al., 2016). Financial difficulties, slow payments, and site clearance difficulties are among the most common owners’ risks in the VCI and other developing countries (Le et al., 2019). In order to minimize those risks, it might be appropriate for owners to seek external skills and experience from competent contractors and consultants to complement their lack of experience and create a clear and simple project plan to execute.

‘Create practical models to assess the changes of schedule and cost’ (Table 2: RII value 0.673; ranked thirteenth overall) is fundamental in achieving success in construction. Constant changes such as those initiated by designers, client requirements, weather, site conditions, late deliveries, economic conditions, etc. that effect schedule and cost are inevitable in construction projects (Yakubu & Sun, 2010). Le et al. (2019) conducted a survey with 103 construction participants in Vietnam and revealed that 94.2% of them experienced delays and 81.6% of them experienced over-budget issues in the past five years. The VCI now needs practical models to manage changes of schedule and cost that fit Vietnam’s conditions. There have been several efforts in the world pertaining to this domain such as mathematical models, artificial intelligence models, etc. However, the efforts are scattered and have not been tested widely within construction settings in Vietnam (Le-Hoai et al., 2008).

‘Improve contracts to equitably allocate risks between parties’ (Table 2: RII value 0.661; ranked fifteenth overall) is a strategic approach for risk management that is essential during project development. Generally, this practice is meant to allocate each risk to the party best able to manage it. In theory, the party in the best position to manage a risk should be able to do so at the lowest cost. For example, to manage the risk from interest and inflation rates, a fluctuation cause should be introduced to require contractor to bear risk of cost increase for the original scope, while owner to bear risk of cost increase for change orders (Ling & Hoang, 2010). This practice could potentially lower each party’s risk premiums and thus, the project’s overall cost (Li et al., 2005).

‘Measurable construction company’s performance for improvement’ (Table 2: RII value 0.653; ranked sixteenth overall) and ‘Measurable projects performance’ (Table 2: RII value 0.651; ranked eighteenth overall) are indicators of project success. This practice utilizes metrics such as key performance indicators (KPIs), performance metrics (Kashiwagi, 2019) to benchmark performance, process, and strategy for improvement. Construction practitioners in Vietnam and other developing countries could benefit from this practice. For example, owners may use metrics to select potential contractors, construction companies may judge their own performance to reveal strongpoints and weaknesses to develop strategies for improvement, and contractors to compare their performance with competitors to learn and change from good practices of others (Luu et al., 2008).

A further CSF is ‘Introduce effective construction management’ (Table 2: RII value 0.653; ranked seventeenth overall). Project management tools and techniques play a vital role in the effective management of a project. It involves managing various resources (workers, machines, money, materials, methods used, etc.) and stakeholders (Sambasivan & Soon, 2007). Mismanaged projects often incur delay and cost overruns (Frimpong et al., 2003). Due to fast development and lack of support infrastructure, construction practitioners in development countries still lack the required knowledge and experience in project management (Le et al., 2019). There is a demand for the involvement of experienced construction managers at various levels such as corporate, process, project, and activity to enhance the overall construction industry performance in Vietnam (Long et al., 2004).

‘Good relationships between both central and local governments’ (Table 2: RII value 0.643; ranked nineteenth overall) and ‘Projects are inspected by government officials’ (Table 2: RII value 0.565; ranked twenty second overall) are two CSFs pertaining to dealing with the government. Good relationships with the government are important for the success of construction projects because they allow owners and contractors to understand, be familiar, and conversant with current approval processes, laws, and regulations. Similarly, having government officials to inspect projects helps identify and resolve existing legal issues that are common in Vietnam to avoid halts. With unresolved regulation and code issues, a project faces the risk of unexpected halt or termination even after design and construction have been well developed.

Employment of innovative strategies to ‘Simplify the bidding process’ (Table 2: RII value 0.606; ranked twentieth overall) and ‘Save time and cost during the bidding process’ (Table 2: RII value 0.597; ranked twenty first overall) are other CSFs pertaining to tendering. Tendering practice in Vietnam has been criticized as time-consuming, complex, expensive, and based on relationships (Thuyet et al., 2007). Improving the quality of tendering system proves effective in shortening completion time, improving quality, and lowering costs of construction works (Thuyet et al., 2007).

Ling & Bui (2010) suggested that as ‘Foreign experts are involved’ (Table 2: RII value 0.515; ranked twenty third overall), it would lead to better project performance in the VCI. Benefits that foreign experts bring to the table include experience, sophisticated technologies, technology transfer, ethics, and professional work attitude. However, the limited access, high cost, and cultural differences to employ foreign experts are common concerns that need to be addressed before introducing the expertise of foreign professionals into projects. Those high barriers are probably the reasons why this CSF is ranked last by all parties.

Table 2: Relative Importance Index and Rankings

Success Factors	Overall		Owners		Contractors		Consultants	
	RII	Rank	RII	Rank	RII	Rank	RII	Rank
All project parties clearly understand their responsibilities	0.745	1	0.761	1	0.793	2	0.636	7
More serious consideration during contractor selection stage	0.738	2	0.733	4	0.807	1	0.636	6
Test contractors' experience and competency through successful projects in the past	0.735	3	0.722	8	0.786	3	0.682	2
Project team members need to be well matched to particular projects	0.735	4	0.756	2	0.786	4	0.614	11
Promote pre-qualification of tenders and selective bidding	0.728	5	0.721	7	0.764	7	0.682	1
Select designer based on experience and past performance	0.728	6	0.716	9	0.779	6	0.670	5
All project parties, especially contractors, understand their responsibility to provide materials on time	0.725	7	0.744	3	0.729	11	0.682	3
Owners understand their responsibility for timely payment to contractors	0.718	8	0.705	12	0.757	8	0.679	4
Change tender selection philosophy from "lowest-price wins" to select the most responsive contractor based on preset criteria	0.710	9	0.699	14	0.779	5	0.625	8
Select high performing consultants to evaluate design works	0.703	10	0.727	6	0.721	12	0.625	9
Adequate resources invested in the pre-construction phase	0.693	11	0.733	5	0.743	9	0.534	18
Have a plan to assist inexperienced owners	0.691	12	0.705	11	0.736	10	0.591	14
Create practical models to assess the changes of schedule and cost	0.673	13	0.716	10	0.686	16	0.568	16
Effective communication between owner and designer	0.662	14	0.680	15	0.671	18	0.607	12
Improve contracts to equitably allocate risks between parties	0.661	15	0.659	18	0.693	13	0.614	10
Measurable construction company's performance for improvement	0.653	16	0.670	16	0.693	14	0.523	19
Introduce effective construction management	0.653	17	0.670	17	0.686	17	0.560	17
Measurable projects performance	0.651	18	0.653	19	0.686	15	0.591	13
Good relationships between both central and local governments	0.643	19	0.705	13	0.600	21	0.583	15
Simplify the bidding process	0.606	20	0.642	21	0.621	19	0.511	20
Save time and cost during the bidding process	0.597	21	0.648	20	0.600	20	0.489	21
Projects are inspected by government officials	0.565	22	0.608	22	0.543	22	0.489	22
Foreign experts are involved	0.515	23	0.528	23	0.521	23	0.477	23

Spearman's Rank-Order Correlation

The Spearman's Rank-Order Correlation (SRC) measures the implied degree of agreement on the ranking among groups of respondents. It is computed with the following formula:

$$\rho = 1 - \frac{6 \times \sum d^2}{n(n^2 - 1)}$$

in which ρ = level of consensus between two groups (0 ≤ ρ ≤ 1); d = the difference in ranking of a risk factor, and n = number of ranking places.

Table 3 shows the results of Spearman's Rank-Order Correlation and significance level calculations among the respondents. The results show that there is generally good agreement between the three groups of respondents in ranking the importance of these CSFs. The highest degree of agreement is between owners and contractors (79%) while the lowest degree of agreement is between owners and consultants (68%). Due to high degree of agreements, the data is considered acceptable for further analysis between all parties.

Table 3: Spearman's Rank-Order Correlation Among Parties

Groups	SRC	Sig. level
Owners - Contractors	0.792	0.001
Contractors - Consultants	0.781	0.001
Owners - Consultants	0.676	0.001

Factor Analysis

The relationships between each of the CSFs were further investigated in order to identify the most significant ones. Factor analysis was used to, first, measure the multivariate interrelationships between and within the CSFs, and second, analyze the structure and correlations between the variables by defining a set of common underlying dimensions (also known as factors or components) (Hair et al., 1998). The Kaiser-Meyer Olkin (KMO) and Bartlett's Test of Sphericity were conducted to verify the legitimacy of factor analysis. In this study, Bartlett's test approximate of Chi-square is 1461.034 with 253 degrees of freedom, which is significant at the 0.001 level of significance, suggesting that the population correlation matrix is not an identity matrix. The KMO statistic of 0.857 is also greater than 0.5 which is satisfactory for the factor analysis.

The Principal Component method was utilized for factor extraction. The Oblimin rotations with Kaiser Normalization rotation method was selected for this analysis. Four (4) components were identified with Eigenvalues to be greater than 1 (shown in Table 4). These four components account for approximately 63.4% of the variances in construction success factors.

Table 4: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	10.238	44.514	44.514	10.238	44.514	44.514	3.160
2	1.732	7.529	52.042	1.732	7.529	52.042	6.408
3	1.491	6.482	58.524	1.491	6.482	58.524	5.099
4	1.130	4.913	63.437	1.130	4.913	63.437	6.502

Table 5 shows the four (4) component loadings extracted from the factor analysis and exclude the factors with loading values of less than 0.5. The four components are interpreted and labeled as follow:

- Component 1 – Improving Management Capability
- Component 2 – Adequate Pre-Planning
- Component 3 – Stakeholders' Management
- Component 4 – Performance-based Procurement

Table 5: Factor Analysis Loading and Results

Components	**Eigenvalue**	Variance (%)	Success Factors	Factor Loading
1	10.238	44.514	Measurable construction company's performance for improvement	0.536
			Introduce effective construction management	0.527
2	1.732	7.529	Owners understand their responsibility for timely payment to contractors	0.800
			Have a plan to assist inexperienced owners	0.736
			Select high performing consultants to evaluate design works	0.631
			All project parties clearly understand their responsibilities	0.625
			Project team members need to be well matched to particular projects	0.595
			All project parties, especially contractors, understand their responsibility to provide materials on time	0.573
3	1.491	6.482	Effective communication between owner and designer	0.555
			Projects are inspected by government officials	0.834
			Foreign experts are involved	0.759
			Good relationships between both central and local governments	0.729
4	1.130	4.913	Promote pre-qualification of tenders and selective bidding	0.910
			More serious consideration during contractor selection stage	0.820
			Test contractors' experience and competency through successful projects in the past	0.731
			Select designer based on experience and past performance	0.522

Component 1: Improving Management Capability

Nowadays, there are many reputable and high-performance Vietnamese contractors such as CotecCons, Hoa Binh, Cofico etc. that could compete and win big projects against foreign competitors. Despite having high quality contractors, the Vietnam construction industry is still lacking competent project managers (Le-Hoai et al., 2008) who can utilize the expertise of those contractors and perform necessary project management tasks to achieve success. This factor suggests that project managers should utilize performance metrics or indicators to improve their management capability. Component 1 is responsible for 44.5% of the total variance of critical success factors (Table 5). There are two CSFs in this group: ‘Measurable construction company’s performance for improvement’, and ‘Introduce effective construction management’.

In order to improve, one first has to be aware of their current performance. The first loading component ‘Measurable construction company’s performance for improvement’ (Table 5: Factor loading 0.536) suggests construction practitioners to benchmark their current performance with measurable metrics for improvement. Determined performance metrics would provide directions for project managers to develop or employ proper strategies to achieve success as indicated by the second loading component ‘Introduce effective construction management’ (Table 5: Factor loading 0.527). Metrics should not only include time, cost, and customer satisfaction, but also those that show the quality or value that the stakeholders are receiving (Kashiwagi, 2019). Chan (2004) also conducted a study on key performance indicators (such as those pertaining to time, cost, value and profit, environmental performance, quality, functionality, etc.) that could be utilized to measure success in construction projects. As different stakeholders have different views on success (Sanvido et al., 1992), the metrics pertaining to performance and success also vary from project to project. It is the project manager’s role to coordinate with all the stakeholders before the project starts to determine a set of performance metrics to be tracked throughout the project. Additionally, common metrics from multiple projects could be compiled in a report to reveal a company’s strongpoints, weaknesses, past performance, and common risk encounters. Such report would be a useful tool for the project managers to develop long-term development strategic plan for their organizations.

Component 2: Adequate Pre-Planning

The pre-planning phase is important as it sets the right conditions such as money, resources, people, communication, etc. to ensure the project runs smoothly. This factor emphasizes the importance of necessary preparations before construction starts and is responsible for 7.5% of the total variance of critical success factors (Table 5). There are seven CSFs components in this group:

- Owners understand their responsibility for timely payment to contractors,
- Have a plan to assist inexperienced owners,
- Select high performing consultants to evaluate design works,
- All project parties clearly understand their responsibilities,
- Project team members need to be well matched to particular projects,
- All project parties, especially contractors, understand their responsibility to provide materials on time,

- Effective communication between owner and designer.

The two highest loading components in this group are related to owners: 'Owners understand their responsibility for timely payment to contractors' (Table 5: Factor loading 0.800) and 'Have a plan to assist inexperienced owners' (Table 5: Factor loading 0.736). Owners keep projects going with their payments; however, they are also the party that cause most project risks and deviations (Elawi et al., 2016). Hence, having a plan to assist owners and ensure that they can fulfill their role comfortably are fundamental throughout the project and should be addressed upfront.

As discussed elsewhere, the design is critical for project success. As projects develop, the cost of changes for design increases, while the effect of those changes decreases. Hence, the design should be evaluated by high performing consultants during pre-construction to ensure quality, constructability, and accurate translation of owner's ideas to the designer. This is presented by the third and seventh loading components in this group (Table 5: Factor loading 0.631 and 0.555, respectively).

'All project parties clearly understand their responsibilities' (Table 5: Factor loading 0.625) is another important component that should be considered pre-construction. A stakeholder not fulfilling their role could slow, or even prevent, project development. That risk could be reduced by having clear and constantly updated project objectives, scope, and plans available to all stakeholders. A project also has higher chance of success when the plans are presented in simple formats with the right level of details (Nguyen Duy et al., 2004). This practice also creates uniform commitment, agreement, and clarity towards project goals. One of the most important responsibilities is timely delivery of materials (Table 5: Factor loading 0.573).

It should be emphasized that project teams, not project managers, implement and deliver projects (Nguyen Duy et al., 2004). In Vietnam, a developing country, it is relatively more difficult to assemble a team of necessary specialists, professionals, and experts to direct projects to success. Hence, additional efforts should be made during Pre-planning phase to ensure that project team members are well matched to project requirements (Table 5: Factor loading 0.595).

Component 3: Stakeholders' Management

This factor emphasizes the stakeholders' management and is responsible for 6.5% of the total variance of critical success factors (Table 5). There are three CSFs in this group: 'Project are inspected by government officials', 'Foreign experts are involved', and 'Good relationships between both central and local governments'.

The government is an important stakeholder as they provide permits, pass laws, and create development plans that have high impacts on construction industry and projects. However, construction projects in Vietnam have been facing high risks of delays and cost overruns due to bureaucratic administrative system (Le et al., 2019). The legal system governing construction projects in Vietnam is still primitive, continues to change unexpectedly, is consistent on various levels, and requires excessive time and effort to obtain permits. Thus, having projects inspected by government officials (Table 5: Factor loading 0.834) and maintaining good relationships with the governments (Table 5: Factor loading 0.729) are necessary measures to address potential legal issues that could delay, halt, or even terminate projects. Due to the complexity in managing different stakeholders, owners could choose to involve foreign experts (Table 5: Factor loading 0.759) as their representatives or construction managers. This is a potential, but temporary, solution for the lack of competent local project managers in Vietnam.

Component 4: Performance-based Procurement

The procurement process is important as it helps identifying the right designers, contractors, and other entities needed to successfully deliver projects. This factor emphasizes on prioritizing performance in tendering and is responsible for 4.9% of the total variance of critical success factors (Table 5). There are four CSFs in this group: ‘Promote pre-qualification of tenders and selective bidding’, ‘More serious consideration during contractor selection stage’, ‘Test contractors’ experience and competency through successful projects in the past’, and ‘Select designer based on experience and past performance’.

Compared to open competitive bidding, pre-qualification and selective bidding (Table 5: Factor loading 0.910) could quickly bring in high quality and reputable contractors to bid on projects. During selection phase, contractors should be considered more seriously (Table 5: Factor loading 0.820) based on criteria other than cost. Past experience and successful projects in the past closely relate to project success as they indicate a contractor’s competency (Nguyen Duy et al., 2004) (Table 5: Factor loading 0.731). However, it is a common misconception that only contractors should be selected based on performance. As construction is a dynamic environment that involves multiple parties, if one party fails to perform its role, the project is likely to fail. Therefore, not only the contractors, the remaining of project team including designers (Table 5: Factor loading 0.522), consultants, and sub-contractors should also be selected based on experience and past performance.

Conclusion

As a developing country, the economy in Vietnam has been growing fast and steady with significant contribution from construction activities. However, multiple studies in the past 15 years identify that there are still risks existing in the Vietnam Construction Industry (VCI)’s projects that hinder performance. Hence, it is imperative to continuously develop research on solutions to improve the VCI performance.

This paper identified 23 Critical Success Factors (CSFs) pertaining to common risk factors in the VCI. A questionnaire survey was developed, administered, and analyzed to assess current effective CSFs with participants from the VCI. The relative importance of those CSFs was revealed from the response data of three main project participating groups (owners, contractors, and consultants). ‘All project parties clearly understand their responsibilities’, ‘More serious consideration during contractor selection stage’, ‘Test contractors’ experience and competency through successful projects in the past’, ‘Project team members need to be well matched to particular projects’, ‘Promote pre-qualification of tenders and selective bidding’ were found to be the most important CSFs. There were no significant disagreements between each party in ranking these CSFs. Further factor analysis examined the principal success factor groupings and resulted into four factors: 'Improving Management Capability', 'Adequate Pre-Planning', 'Stakeholders' Management', and 'Performance-based Procurement'. These four factors emphasize the basic elements of CSFs for project risk management in Vietnam. They should be constantly considered by VCI project managers throughout the development of projects.

Other countries that face similar construction risks as Vietnam would also find these results useful. The findings could help construction practitioners in developing countries improve their understanding in project management. Project managers could make better plans and form strategies accordingly in their projects to ensure performance with the suggested CSFs and analyzed factors.

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Comparing the Chinese Construction Industry with Other Developing Countries to Identify an Applicable Solution to Low Construction Performance

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The Chinese Construction Industry (CCI) has become one of the largest in the world within the last 20 years. However, due to its rapid growth it has been experiencing issues causing the industry to struggle with delivering high performing projects. Due to the differences between developed and developing countries construction industries, research from other developing countries that were similar to China (Vietnam and Kingdom of Saudi Arabia) were used to help identify solutions to improve the CCI. Previous research has identified the major risks in Vietnam and Saudi Arabia. It has also been identified the only solution that has documented evidence that it can improve construction performance is the Best Value Approach that was developed in the United States at Arizona State University. A literature research was performed identifying the major risks and issues that have been documented in the CCI. These risks were then compared to that of the Vietnam and Kingdom of Saudi Arabia's construction industry risks. It was identified that the majority of the top risks were similar in all three countries. Identifying that developing countries have been experiencing the same issues. This also identifies that the Best Value Approach might be a solution to help improve the CCI.

Keywords: China, Construction, Performance, Risk, Developing Country, Best Value Approach, Vietnam, Saudi Arabia.

China Construction Industry Issues

In the last 20 years China's Construction Industry (CCI) has grown to be one of the largest in the world. Each year China spends around $850 billion to support its population and business growth (Trading Economics, 2018). A study performed in 2009 identified it as the largest contributor to the international construction industry (Zhao et al. 2009). This rapid growth and the size of the CCI has caused many issues dealing with the performance and efficiency of construction projects, and the quality of the construction being built. There have been multiple studies that have been performed to verify these issues, but due to the physical size, number of people involved in the CCI, and the amount of projects that are being performed each year, it has been difficult to accurately verify how extensive and severe these issues are affecting the CCI. Few studies have been able to collect documentation on the performance of construction projects in the CCI. The research that has been performed has found the following:

1. Productivity and efficiency are poor (Shen et al. 2011, Li 2003, Zhao et al. 2009)
2. Perceived performance issues, but little documentation of actual performance and quality (Yang et al. 2010, Hu et al. 2018)

Low Productivity and Efficiency

The CCI plays an increasingly important role in the world. But its performance is poor compared with that of its foreign counterparts, and other developed countries. Despite the significant development of the CCI, the low industry performance in various domains is frequently criticized by researchers (e.g., Deng et al. 2013; Liu et al. 2013; Liu and Deng 2009; Sha et al. 2008; Wang 2004; Wang et al. 2006; Shen et al. 2006; Wei and Lin 2004). One set of research findings stated that compared to the U.S. construction industry, the CCI employed 31 times more people and the average output per person is only 5% of U.S.'s workforce and 6% of output of the average Japanese workforce. Although CCI spends more than the U.S., it still delivers 23 times less construction services than the U.S., which shows the major issue the CCI deals with regarding their low productivity and inefficiency (Zhang et al. 2008, Xu et al. 2005). Insufficient expenditure on machinery and equipment also affects the labor productivity negatively. In the year 2005, the equipment fee accounted for less than 7% of the total project fee in China, while it accounted for 20% in the U.S. The official statistics revealed that in 2006: 1) the overall labor productivity in terms of value added is Chinese Yuan 25,741 per person; 2) the value of machines per laborer is Chinese Yuan 9,109 per person; and 3) the power of machines per laborer is 4.9 kW per person. All these figures are very low compared with western construction industries (Zhao et al. 2009).

Perceived Performance Issues

Currently, the CCI does not have a lot of information on construction performance. Failure of performance measurement in the construction industry has been criticized in literature, including a review by Yang et al. (2010). Another study also identified that there was minimal literature that simultaneously measures overall performance, efficiency, and effectiveness (Hu et al. 2018). A preliminary literature research revealed that there is no documentation on the CCI's overall performance published. There were only a couple of studies performed that found performance information on construction projects in China. One study researched stakeholder satisfaction. It found that out of 200 construction projects in China in 2005, 24.3% had violated related regulations and only 13% could be ranked as "good quality" (Zhang et al. 2008). Similarly, one study surveyed 139 construction firms in China which one result indicate that 'improving construction quality' as the most common competition method, indicating the significance of quality issues for Chinese firms (Wang et al. 2006). Other research found that in 2005, only 12.85% of 515 government projects in Shenzhen and Hong-Kong completed within the scheduled completion date [of the projects delayed the average delay was 21.34% over the original schedule]. Also, in 2004, 73% of 30 government projects reported being 20.3% over the original budget (Zhang et al. 2008).

The CCI, along with many other developing countries, often looked to more developed construction industries to find solutions to their issues (Chen, 2020). However, many developing countries have not found success in using developed countries' solutions (Chen, 2020). This could be contributed to the fact that developing nations do not have the same issues as developed countries, thus their solutions do not address the need of the developing country. Another reason for this is because solutions created by developed nations often do not resolve the issue (Chen, 2020). Developed nations are also trying to figure out how to improve the performance of their construction industries.

Performance recorded over the past 30 years in two of the most developed nations (United Kingdom and United States) are as follows:

- Research conducted in the U.K. has documented construction performance in showing minor improvements from 2000 to 2011 in certain areas, but continues to suffer in others (Kashiwagi, 2013, Rivera, 2016):
    - Overall customer satisfaction increased from 63% to 80%.
    - Customer satisfaction for projects over 5M Euros was at 73%.
    - Projects completing on time increased from 28% to 45%.
    - Projects completing on budget increased 50% to 63%.
    - Contractor profitability declined to 5% from 7% in 2010.
- Studies have also been conducted in the U.S. showing similar results of construction non-performance (Kashiwagi, 2013, Rivera, 2016):
    - Productivity has decreased by 0.8% annually.
    - Construction companies have the second highest failure and bankruptcy rate of 95%.
    - Over 90% of transportation construction jobs are over budget (Lepatner, 2007).
    - Almost 50% of time is wasted on the job site (Lepatner, 2007).
    - The average percent over budget amount and percent delay amount is 28% and 53% (Rivera, 2016).

Comparing Other Construction Industries to the China Construction Industry (CCI)

In a previous study conducted by the researcher (Chen, 2020), it was found that the CCI and its conditions are very similar to other developing nations (10 in total. See Table 1.1). Of the 10, only Vietnam and the Kingdom of Saudi Arabia (KSA) were identified as the two countries most similar to the CCI. The factors used to identify similarities with the CCI were the following (see Table 1.1):

1. Construction GDP %
2. Corruption Index
3. Construction GDP Increase

Table 1 shows the breakdown. Of the similar countries, the researcher was only interested in countries that were most similar to the CCI. Five countries [Bahrain, Indonesia, Mongolia, Thailand, and Turkey] were disqualified because they were not the most similar in all three factors. Of the remaining 5 that were most similar to the CCI, the Philippines and Oman were disqualified due to a lack of documentation on their construction industries. This made it impossible to do further research on them (see Table 2). India shows the lowest GDP growth with only a 14% increase. Given this, India stands out as an outlier among the five comparable countries, so it was disqualified. The only two countries remaining that had documentation were

Vietnam and KSA. These would be the countries the researcher used as the primary comparison with the CCI.

Table 1 shows that Vietnam, KSA and China's construction industries all contributed a similar percentage to their countries overall GDP. They also had close corruption index scores showing that the environment and stability of the country's industry is similar [all within 7 or less from each other]. Lastly, all three were found to have large growths in the last 10 years of their construction GDP.

Table 1: Comparison of Construction Industry between Different Developed Countries

Country	Corruption Index Score	Construction GDP ($)	Construction GDP (%)	Construction GDP Increase (2010 – 2017)
Saudi Arabia	46	$8.64B	4.8%	38%
Oman	45	$5.94B	8.9%	74%
Bahrain	43	$0.59B	1.8%	34%
Turkey	41	$8.08B	0.9%	75%
China	40	$844B	6.8%	172%
India	40	$35.7B	8.0%	14%
Mongolia	38	$0.22B	2.1%	80%
Indonesia	37	$19.21B	2.1%	86%
Philippines	35	$4.3B	6.2%	150%
Thailand	35	$2.27B	2.5%	36%
Vietnam	33	$1.29B	4.4%	40%

Table 2: Reference of Construction Industry from Different Developed Countries

Country	Reference of Construction Industry
Saudi Arabia	45
Oman	1
China	46
Philippines	0
Vietnam	50

Potential Solution

As shown in Table 1 and 2, Vietnam and KSA have the most similar construction industries compared to China. Interestingly, of the publications identified for Vietnam and KSA, both have documented poor performance in their construction services. It was identified that major research studies had been performed on both the Vietnam Construction Industry (VCI) and the Kingdom of Saudi Arabia Construction Industry (KSACI) that identified the best solution to resolve their construction non-performance and minimize their risks was the Best Value Approach (BVA). Due to the similarities of VCI and KSACI with the CCI, the BVA may also be a solution for the low performance of the CCI. This next section will identify research conducted on the Best Value Approach.

The Best Value Approach

The Best Value Approach (BVA) has been the only project delivery approach that has repeated documented testing with improved project performance. It has been tested in the entire supply chain (construction and non-construction services) (Rivera, 2017).

It was derived from the industry structure model (IS) (see Figure 1). The IS model splits the industry up into two main quadrants:

1. The Best Value quadrant that has high competition and performance; and
2. The Price Based quadrant that has low competition and performance.

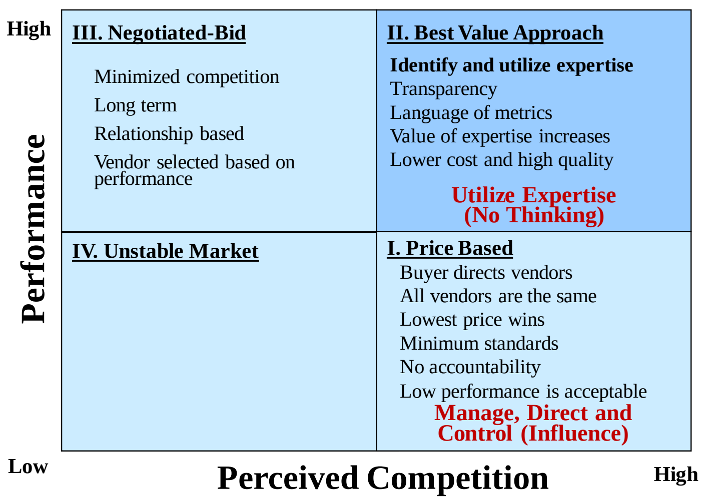

Figure 1: Industry Structure Model.

The model identifies that low performance is caused due to buyers trying to manage, direct, and control (MDC) vendors. The only way to move to the Best Value quadrant is to utilize the expertise of the vendor, by moving the management and control of the project to the expert vendor.

The IS model identifies the following buyer traditional activities that are used to MDC vendors (Kashiwagi, 2018; PBSRG, 2018):

- Creating technical requirements and specifications.
- Partnering and developing relationships with vendors to enable the client to be involved with the management and development of the service.
- Using the contract as leverage over the vendor.
- Using a project manager to manage a vendor after they were awarded a contract.

The IS model also identifies that the following activities will enable buyers to utilize the expertise of vendors:

- Minimize involvement in technical details of services.

- Move buyer activities to that of quality assurance (ensuring the vendor has created a plan and is measuring their performance through non-technical metrics) instead of quality control (ensuring the vendor is performing all their technical work correctly).
- Require vendors to tell the client what the technical specifications and requirements should be.
- Utilize internal buyer personnel to help and protect the vendor.

The BVA was developed to help buyers to understand and move perform the activities that enable them to utilize the expertise of vendors. The BVA splits a project up into three major phases (selection, clarification, and execution) (see Figure 2):

Selection Phase

All vendors compete based on their level of expertise instead of their technical scope of work. During this phase, the vendors are not given technical requirements or specifications, but a list of expectations and explanation of "what the client thinks they want". They are selected upon their past performance metrics, ability to identify risk, and capability of their key personnel. The highest ranked vendor moves into the clarification phase.

Clarification Phase

This is the most important phase, as the vendor with the highest level of expertise is now required to create their scope of work and technical requirements which are required to:

- Explain how they will accomplish the work efficiently and with high customer satisfaction
- Identify their plan from beginning to end, all risks they do not control, all major milestones, how they will measure their performance, and justify their costs
- Respond to the client's concerns and feedback about the vendor's plan and the vendor must address those concerns in their plan

Regardless, if the concerns from the client are technical or non-technical, the vendor is required to resolve the concern using non-technical language. The contract is only signed when the client is comfortable with the vendor's plan, otherwise, the vendor will be eliminated from clarification and the next in line vendor will be notified for clarification.

Execution Phase

Upon signing the contract, the contractor can proceed to work according to their plan. Since the vendor was the entity that developed the plan and the metrics, it has now put them in full control of the project. Performance will be tracked and posted online for each contractor through Weekly Risk Reports (WRR) which the contractor will turn in on every Friday. If ever another stakeholder tries to control the expert, that is also reported on the WRR and the vendor identifies what the impact that control will have on the project's performance.

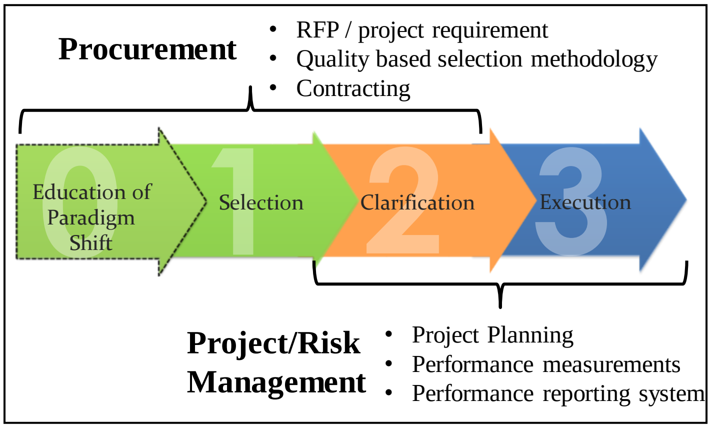

Figure 2: The Best Value Approach.

Many of these ideas are different from the traditional delivery models. However, BVA system has documented the following performance (Rivera, 2017; PBSRG.com, 2018):

- 2,000+ projects and services delivered (construction and non-construction).
- $6.6B of projects and services delivered with a 98% customer satisfaction and 9.0/10 client rating of process.
- Services delivered: construction, facility maintenance, IT, professional (design), redesign of systems and organizations and supply chain applications.
- $18M in research funding generated, due to the effectiveness of decreasing buyer cost of services on average by 31% (57% of the time, the highest performing expert was selected and was the lowest cost).
- Contractors/experts could offer the client/owner 38% more value and decreased client efforts by up to 79%.
- 90% of all project cost and schedule deviation is caused by the owner's non-expert stakeholders.
- Change order rates were reduced to as low as -0.6% (Rivera, 2017).
- CIB W117 has worked with over 123 unique clients (both government and private sector) and received 12 National/International Awards.
- 5 to 30 percent cost savings are achieved on the projects.
- The BVA is the most licensed technology to come out of Arizona State University licenses (63).
- It is internationally recognized through repeated testing (Canada, Netherlands, Sweden, Norway, Finland, Botswana, Malaysia, Australia, Democratic Republic of Congo, France). Education efforts are in Poland, Saudi Arabia, India, Vietnam and China.
- Been audited four times: The State of Hawaii Audit [Kashiwagi et al. 2002; State of Hawaii Report 2002 (DISD)]; The Dutch Study on the Impact of PIPS (Duren & Doree, 2008); The Corps of Engineers (COE) PARC, 2008 (Kashiwagi, 2018); The Western States Contracting Alliance (WSCA) Agreement, 2011 (PBSRG, 2018).

Proposal

Due to the China Construction Industry (CCI) environment and conditions being similar to Vietnam and the Kingdom of Saudi Arabia (KSA), the researcher asserts the following proposals:

1. The CCI will have similar risks and issues as Vietnam and KSA.
2. If the CCI risks are similar to Vietnam and KSA, the Best Value Approach may also be a potential solution to help it overcome its low construction performance.

Methodology

The following research proposes to investigate whether the China Construction Industry (CCI) has similar risks to Vietnam and the Kingdom of Saudi Arabia (KSA), and if the Best Value Approach (BVA) is a potential solution to help it improve its performance. To investigate this proposal, a literature research will be performed as follows:

1. Perform a literature research in the CCI and compile a list of top risks.
2. Analyze and prioritize the risks in terms of most to least frequently documented.
3. Repeat steps 1 and 2 for the VCI and KSACI.
4. Compare and analyze the CCI risks to those of VCI and KSACI.
5. Research which risks BVA seeks to address in Vietnam and KSA to investigate if BVA can mitigate the same risks in the CCI.

Literature Research on the Risks in China's Construction Industry (CCI)

To identify the major risks in the CCI, a literature search was performed through 5 databases with more than 6891 journals. The five databases included:

1. Emerald Journals
2. ABI/Inform
3. Google Scholar
4. ASCE Library
5. EI Compendix

These databases combined had the following characteristics:

1. Updated weekly with articles from 55 different countries (EI Compendex).
2. Has over 10 million papers and more than 650,000 are added annually (EI Compendex).
3. Maintains a database of articles from multiple construction related areas (Emerald Journals).
4. Publications from the entire world on topics that include facility management, engineering, construction, and project management (ABI/Inform).
5. Contains all articles and papers that can be found on the internet (Scholar Google).

Six search terms were used to look for articles in each database (See Table 3). These terms were derived from looking at other research efforts that performed literature research on construction risks and the terms that they used. For each search term for each database the following information was tracked:

1. The number of articles that the search term brought up.
2. The number of articles that were relevant to the research topic.
3. The year the article was published.

The researchers read each abstract from articles published since 2003. Each abstract that was relevant to the research, the full paper was downloaded and read for information regarding risks in the CCI. Table 3 identifies the number of relevant papers that were identified from each database.

Table 3: The Number of Identified Relevant Papers from Each Database

Search Term	**EI Compendix**	**Relevant Papers**	**Year touched**	**Emerald Journals**	**Relevant Papers**	**Year touched**	**ABI/Inform**	**Relevant Papers**	**Year touched**	**Google Scholar**	**Relevant Papers**	**Year touched**	**ASCE Library**	**Relevant Papers**	**Year touched**
CCI	3356	3	2003	12412	4	2001	34000	1	2003	41400		2003	4911		2004
CCI Risks	5000	4	2003	9440		2001	11000	1	2003	347000	2	2003	4635	1	2004
CCI Issues	11897	2	2003	14706	2	2001	19455	1	2003	179	1	2003	6625		2004
CCI Performance	2199	4	2003	14366	1	2001	16522	1	2003	1740000	3	2003	10197	7	2004
CCI Risk Management	3855	1	2003	8707	2	2001	13135	1	2003	72300	2	2003	4274	2	2004
CCI Inefficiency	805	0	2003	2042		2001	845	0	2003	34900		2003	622		2004
Total Hits →	27112	14		61673	9		94957	5		2235779	8		31264	10	

The literature search identified 46 relevant publications on construction risks in the CCI. Those 46 publications identified 72 risks. Each risk was prioritized based upon the frequency in which they appeared in the studies. Table 4 identifies the risks that appeared most frequently in the studies and gives an example of how documentation was kept on each risk appearing in the different publications. Of the 72 risks identified, 42% were only found in one publication and 15% were found in only two publications. Only 43% of the risks were found in more than three of the publications.

Table 4: Identified CCI Risks in the Literature Research

Major Categories	Addressing sustainable challenges in China: The contribution of off-site	Barriers to Lean implementation in the construction industry in China	Compare China Mainland and China Hongkong Contractors' Productive Efficiency	Competitive Tendering Practice in Chinese Construction	Enhancing buildability in China's construction industry using Singapore's buildable design appraisal system	Evaluation of Risks on Construction Projects	Fan, Y. (2002), "Guanxi's Consequences: Personal Gains at Social Cost", Journal of Business Ethics, 38(4), pp.371-380	IDENTIFICATION AND ALLOCATION OF RISKS ASSOCIATED WITH PPP WATER PROJECTS IN CHINA	Identifying elements of poor construction safety management in China	Key Issues and Challenges of risk management and insurance in China's construction industry: An empirical study	Management of Uncertainties and Consequential Costs for Construction Projects in China	Managing Construction Industry Development in China	Managing construction projects in China-the transitional period in the millennium	Mannion, R. and Smith, P. (1997), "How purchasing decisions are made in the mixed economy of community care", Financial Accountability and Management, 13(3), pp.243-260.	On The Risk Assessment and Precaution of the Agent Construction System	Performance and Strategy of Chinese Contractors in the International Market	Project Culture in the Chinese Construction Industry: Perceptions of Contractors	Research on the governance structure of different agent-construction system models in government investment projects	Risk factors affecting practitioners' attitudes toward the implementation of an industrialized building system: A case study from China	Su, C., Sirgy, M.J. and Littlefield, J.E. (2003), "Is Guanxi Orientation Bad, Ethically Speaking? A Study of Chinese Enterprises", Journal of Business Ethics, 44(4), pp.303-312	Theory and practice of agent construction system of government investment projects	Understanding the risks in China' s PPP projects: ranking of their probability and consequenc	Risk factors affecting practitioners' attitudes toward the implementation of an industrialized building syste	Risk Factors for Project Success in the chinese construction industry	Analyzing Causes for Reworks in Construction Projects in China	Market Structure, Ownership structure and performance of China' s construction industry	An overview of the Chinese construction market and construction management practice	Development Model for Competitive Construction Industry in the People' s Republic of China	Project Management in the Chinese Construction Industry Six Case Study	The construction Industry in China: Its Bidding System and Use of Performance Information	
Legal and Contract Issues				1				1		1	1		1		1						1	1		1	1			1		1	12
Relationships and Guanxi		1	1				1				1			1			1			1		1						1	1	1	11
Outdated Technology				1				1								1			1			1	1		1			1		1	9
Lack of expertise in construction services	1	1											1						1				1	1	1				1		8
Management Skills		1	1									1							1			1	1	1	1						8
Project Financing				1				1							1	1						1	1	1	1						8
Skill level of labor	1	1	1					1					1			1			1					1							8
Government Control				1		1		1					1						1			1						1			7
Bureaucracy in organizations		1	1	1				1																1		1					6
Government Instability and Politics								1			1											1	1		1				1		6
Owner control and decision making						1							1		1		1							1	1						6
Quality and Buildability of Design Drawings					1											1			1				1	1	1						6
Corruption								1			1							1				1								1	5
Infrastructure support								1														1		1	1		1				5
Lack of Government Regulation and Standards	1																		1			1	1					1			5
Market Instability								1											1			1			1				1		5
Type of Procurement Model		1																				1				1	1			1	5
Communication between stakeholders				1	1																		1		1						4
Current CCI Culture										1	1						1								1						4
Delay in Payment									1													1		1	1						4
Instability of currency value								1			1											1		1							4
Procurement Administration				1		1																1					1				4
Approval delay by the client or government													1									1		1							3
Lack of Government Support	1	1																										1			3
Poor integration for the supply chain	1																		1			1									3
Transporting materials																			1				1	1							3
Unforeseen risks															1							1			1						3
Contractor Overstaffing			1																									1			2
Design professional's inability to estimate construction costs					1																			1							2

Table 5 shows the top 15 risks that appeared the most in the literature search. The highest ranked risk was *Legal and Contract Issues*, it appeared in 12 publications (40%). The other top risks included: Relationships and Guanxi, Outdated Technology, Lack of expertise in construction services and Management Skills.

Table 5: Top 15 Risks of China's Construction Industry

Risks	# Relevant Publications
Legal and Contract Issues	12
Relationships and Guanxi	11
Outdated Technology	9
Lack of expertise in construction services	8
Management Skills	8
Project Financing	8
Skill level of labor	8
Government Control	7

Bureaucracy in organizations	6
Government Instability and Politics	6
Owner control and decision making	6
Quality and Buildability of Design Drawings	6
Corruption	5
Infrastructure support	5
Lack of Government Regulation and Standards	5

In further analyzing the 72 CCI risks, the researcher grouped the risks into different categories to identify any patterns. The researcher identified seven main categories that encompassed all the risks. Table 6 identifies the seven main categories, the definition of each category and the percent of risks that were associated with that category.

Table 6: Risks Categories and Definition

Categories	Definition	Risks	% of Risks
Management, Direction, and Control (MDC)	Risks involving the buyer or government managing, directing or controlling the contractor in any way.	Legal and contract issues, change of scope due to a stakeholder of a project, decision making of the buyer, requirements and approvals, and government regulations.	23.7%
Non-Transparency	Risks being caused due to issues in communication, misunderstandings, complexity, relationships, lack of accountability or support from management.	Guanxi, organizational bureaucracy, government politics, corruption, and risk sharing.	16.6%
Finance	Risks caused due to financial aspects of a project or financial conditions of the country.	Market and currency instability, delay in payment to the contractor, contractor mismanagement of project funds, rapid growth of skilled labor cost and contractor lending issues.	11.4%
Vendor Capability	Risks being caused due to the contractor/vendor not being capable of delivering high performing projects.	Lack of expertise and management skills, Inability to create quality design drawings, inability to manage labor supply, high worker turnover rate, no insurance, insufficient safety measures, and a lack of understanding of lean and efficiency principles.	10.4%
Material and Technology	Risks caused due to not having access or a knowledge of the latest technology and materials.	Outdated technology, outdated construction methods, materials required to be replaced during construction, and unknown capability of materials.	10.4%
Procurement	Risks caused due to how buyers select the contractor.	Type of procurement model, buyer low bidding projects, not hiring the right contractor, and the administration of procuring a construction service.	5.2%
Lack of Information	Risks caused due to a lack of information of both the buyer and contractor.	Unforeseen risks and inadequate site information.	1.9%

After prioritizing the categories, the first two categories (MDC and Non-transparency) included more than 40% of all the risks. Interestingly, despite many different reasons for non-performance in the CCI, it was identified that the biggest issues did not deal with the Chinese contractors' ability to deliver high quality construction. It was identified that it dealt more with the interaction between the buyer and the contractor. This would also match up with the analysis on the individual risks (see Table 4), as *Legal and Contract Issues* and *Relationships and Guanxi* were the two most frequently occurring risks in the 46 publications that were documented.

It was also identified that although vendor capability only included 10.4% of all the risks, 3 out of the top 15 risks involved the vendor's lack of capability. For the categories of *Financing and Materials and Technology*, it was also found that each one of these had one risk in the top 15 most frequent risks.

Risk Research Performed on the Vietnam and Kingdom of Saudi Arabia (KSA) Construction Industries

In the last five years, two research studies at Arizona State University were performed by PhD candidates from the Kingdom of Saudi Arabia (KSA) and Vietnam on the major risks that KSA and Vietnam have documented and are currently facing. Both research efforts performed in-depth literature research compiling all information on previous studies performed, on the KSACI and the VCI, identifying and prioritizing construction risks and issues. These research efforts also surveyed construction professionals in their countries to validate previous research and identify any risks the industries are currently facing.

Saudi Arabia Risk Research (Algahtany, 2018)

In 2017, Mohammed Algahtany, PhD candidate researcher, performed research identifying risks and issues construction organizations were facing in the Kingdom of Saudi Arabia (KSA). Mohammed performed both a literature research and conducted a survey questionnaire to collect the information. The literature research performed, reviewed all previous research performed identifying major risks that had occurred on KSA construction projects from 1977 to 2017. The research found 24 publications [18 of which were published in refereed journals]. From these 24 publications, 32 risks were identified and prioritized by the frequency in which they occurred. Dr. Mohammed then surveyed construction organizations that were certified by the Ministry of Municipal and Rural Affairs, a KSA government organization in charge of delivering all KSA government construction. The survey asked the construction organizations to evaluate each of the 35 risks (3 risks were added due to consultation with a KSA construction expert) on a 5-point scale for both severity and frequency. The risks were then prioritized using the Importance Index, which considers both the severity and the frequency rating. Table 7 is an example of some of the top risks prioritized. To see the full list, please refer to the original study (Algahtany, 2018).

Table 7: The Overall Importance of Risks in the Saudi Construction Industry

Risk Factor	FI	Rank	SI	Rank	II	Rank
1- Owner's related risks						
Delay in progress payments by owner	90.740	2	96.559	1	87.618	1
Owners' practice of assigning contracts to lowest bidder	91.111	1	86.956	3	79.227	2
Slow decision making by the owner	79.629	5	82.888	6	66.004	3
Change orders by owner during construction	81.481	3	79.354	18	64.659	4
Excessive bureaucracy in the owner's administration	81.481	3	79.318	19	64.629	5
Delay in approving shop drawings and sample materials	77.037	7	82.173	7	63.304	8
Owner's team lack of experience	77.037	7	79.775	15	61.456	10
Owner's poor coordination with the construction parties and government authorities	75.555	10	80	12	60.444	11
Changes in specifications during construction	71.851	16	80	12	57.481	14
Unrealistic contract duration	72.222	13	79.565	16	57.463	15
Interference by owner in the construction operations	75.849	9	73.333	30	55.622	18
Additional work due to changes in the scope of the project	71.111	18	76	27	54.044	21
Difficulties in obtaining work permits	69.629	22	76.179	25	53.043	24

Vietnam Risk Research (Le; et.al, 2019)

In 2018, Nguyen Le, PhD candidate researcher, performed research investigating the Vietnam construction industry and the risks that were most impactful to their construction performance. As with Mohammed's KSA construction research, Dr. Le performed both a literature research and survey research of the construction professionals in Vietnam. The literature research looked for any studies performed within the last 15 years that identified non-performance causes in Vietnamese construction projects. Dr. Le reviewed more than 100 published papers and identified only 11 studies related to non-performance construction causes in Vietnam. These studies identified 23 risks that Vietnam currently faces in their construction industry. These risks were prioritized based upon frequency. Table 8 is an example of some of the top risks prioritized. To see the full list, please refer to the original study (Le; et.al, 2019).

Table 8: Top Risk in Vietnam Construction Industry from Literature Research

No.	Top Risk in Vietnamese Construction Industry	Agreed Frequency
1	Poor design capacity and the frequent design changes	73%
2	Incompetent contractors	64%
3	Incompetence of project management	64%
4	Financial difficulties of owner	64%
5	Financial difficulties of contractor	55%
6	Poor site management and supervision	55%
7	Corruption	45%
8	Lack of experience in complex projects	36%
9	Slow payment of completed works	36%

10	Bureaucratic administrative system	36%
11	Lack of accurate historical information	27%
12	Interest and inflation rates	27%
13	Unpredictable government policies and priorities	27%
14	Incompetent subcontractors	27%
15	Slow site handover	27%

Using the research from PhD Candidates Nguyen Le and Mohammed Algahtany, the researcher created an adjusted list of top risks by combining the risks seen in Vietnam and KSA. A comparison analysis identified that 80% of the top risks of the Vietnam Construction Industry (VCA) matched the top risks of the Kingdom of Saudi Arabia (KSACI). Both studies suggest that the Best Value Approach (BVA) is a potential solution to address risks in the VCA and KSACI.

Risk Comparison of the China Construction Industry (CCI) with the Construction Industries of Vietnam (VCI) and the Kingdom of Saudi Arabia (KSACI)

According to the data found in the literature search, 100% of the VCI and KSACI risks are found in the CCI (see Table 9).

Table 9: CCI Risk Comparison with KSACI and VCI Risks

Top VCI and KSACI Risks	CCI Risks
Approval delay by the client or government	x
Bureaucracy in organizations	x
Changes to the initial design	x
Communication between stakeholders	x
Corruption	x
Delay in Payment	x
Government Instability and Politics	x
Inadequate Site Information	x
Infrastructure support	x
Instability of currency value	x
Lack of expertise in construction services	x
Management Skills	x
Market Instability	x
Owner control and decision making	x
Project Financing	x
Quality and Buildability of Design Drawings	x
Skill level of labor	x
Type of procurement model	x

On the other hand, each country has a different prioritization of each list of risks. Table 10 below shows a list of the top 10 risks in CCI. The table marks whether each of these top risks were also top risks in the VCI and KSACI. The data shows that 5 of the top 10 risks in CCI were also top risks in KSACI and VCI. Of the 5 risks that were not top risks of the VCI and KSACI, 4 of them are government related issues (Legal and Contract Issues, Relationships and Guanxi, Government Control and Government Instability and Politics) that fall into the management, direction and control (MDC) and non-transparency categories.

Table 10: Top CCI Risks Vs. VCI and KSACI

No.	Top 10 Risks in CCI	Top VCI and KSACI Risks
1.	Legal and Contract Issues	
2.	Relationships and Guanxi	
3.	Outdated Technology	
4.	Lack of expertise in construction services	x
5.	Management Skills	x
6.	Project Financing	x
7.	Skill level of labor	x
8.	Government Control	
9.	Bureaucracy in organizations	x
10.	Government Instability and Politics	

Applicability of the Best Value Approach (BVA) with China's Construction Industry (CCI)

From the risk analysis of the VCI and KSACI, it was identified that the CCI is experiencing all the same risks in their top risks. However, 5 of the top 10 CCI risks (50%) were not risks found in the VCI and KSACI. Due to past research suggesting that the BVA effectively addresses issues created by all of the VCI and KSACI risks identified and 50% of the CCI's top 10 list, the researcher proposes that the BVA can also help the CCI's low construction performance (Algahtany, 2018; Le; et.al, 2019).

Conclusion

Due to the rapid growth of China's Construction Industry (CCI), it has been difficult to maintain a high level of performance on its construction projects. Compared to other similar developing countries (Vietnam and the Kingdom of Saudi Arabia (KSA)) that have also seen a large growth in their construction industries in a short amount of time, they are also experiencing the same issue.

Literature research found that both Vietnam and the KSA have both had research performed to identify the major risks they are facing and the solution that could best help them overcome their issue of construction non-performance. Both research results identified that there has been only one delivery approach that has documented evidence showing that it can minimize the risks these countries are facing and improve their construction performance. This delivery approach is the Best Value Approach (BVA).

A literature research was performed to identify the major risks the CCI is facing and compare them to the Vietnam Construction Industry (VCI) and the Kingdom of Saudi Arabia Construction Industry (KSACI). The results of this research identified that the CCI is facing all of the top risks identified by the VCI and KSACI. However, the VCI and KSACI differ from the CCI because only 50% of the CCI's top 10 risks are also found in the VCI and KSACI's top risks. The remaining 50% of the CCI's top risks are unique to the CCI, four of which are Chinese government related issues (Legal and Contract Issues, Relationships and Guanxi, Government Control and Government Instability and Politics). This could be due to several factors. One of the major factors could be due to the socialist government of China, in which, the government becomes both the buyer and the contractor in most construction projects (Zou et al. 2007; Zou 2007; Liu et al. 2013; Zhang et al. 2008; Xu et al. 2005). It has been concluded that due to the CCI having most risks similar to the VCI and KSACI, it is a candidate to utilize the Best Value Approach to help its low construction performance.

Recommendations

While this research suggests that China's Construction Industry (CCI) faces similar risks compared to the Vietnam Construction Industry (VCI) and the Kingdom of Saudi Arabia Construction Industry (KSACI), China is unique in its issues with government involvement. The researchers recommend additional research to investigate the Best Value Approach (BVA) as a potential solution for the CCI's non-performance issues. The researchers recommend surveying CCI stakeholders to investigate whether the BVA concepts can improve the CCI and the potential of the BVA being able to be implemented in the CCI.

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The Effect of Expertise on Project Complexity

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Project complexity has commonly been cited as a major cause of poor project performance (Al-ahmad et al, 2019). Although literature has identified various methods to measure and define project complexity, research insights did not find an explanation of how to reduce project complexity or its effect on project performance. Expertise has been identified as a potential solution; however, little is known about the extent of impact that expertise may have on project complexity. Using a multimethod approach inclusive of literature, survey and interview research we investigate the "effect' of expertise on project complexity. We analyzed the effect of expertise on 22 unique project complexity factors. Data consists of 97 survey respondents and 15 interview participants. The research led to the following results which should be incorporated into future models: (1) expertise reduces project complexity, (2) experts do not perceive ICT projects as complex while nonexperts perceive ICT projects as complex, and (3) experts' challenges that relate to project complexity factors correspond to project stakeholders as they ultimately fall outside the control of the expert.

Keywords: Expert, Expertise, Complexity, ICT, Project Performance, Project Complexity Model, Project Complexity Factors

Introduction

The information communications technology (ICT) industry has struggled with performance issues for years (Kashiwagi, 2018a) with failure to be completed on time and on budget as high as 84% (Standish Group, 1994). Many countries including the Netherlands, Australia and the United Kingdom have performed governmental inquiries due to massive losses on ICT projects (Legislative Assembly of the Northern Territory, 2014; Public Administration Committee, 2011; The House of Representatives of the Netherlands, 2014).

Project complexity has commonly been cited as the cause of poor project performance (Al-ahmad et al, 2019; Xia & Lee, 2004; Sauer & Cuthbertson). The Standish Group (2016) identified 14% of "very complex" projects are completed on time, on budget and with a satisfactory result for the client. Sauer and Cuthbertson (2003) analyzed data collected from 1,500 practicing ICT project managers and identified project complexity resulted in lower project performance in terms of being on time and on budget. As the ICT industry becomes more integrated into society through technological advances and automation, firms require approaches and solutions to handle project complexity in order to stay in operation (Bakhshi et al., 2016; Qureshi & Kang, 2014).

Project Complexity

Literature provides multiple definitions of project complexity; however, there is not a generally accepted definition (Vidal & Marle, 2008). The majority of research in project complexity has focused on measuring project complexity through the project conditions inclusive of structural, uncertainty, socio-political, and dynamic complexity. Structural complexity relates to the many-varied interrelated parts of a project described by the attributes of size (number), variety and interdependence (Baccarini, 1996; Geraldi et al., 2011; Williams, 1999). Uncertainty includes the understanding of the current state; how current factors will interact and the impact of those factors on the future state of the project. Uncertainty factors can be described by the attributes of experience, novelty, ambiguity and availability of information (knowledge). Socio-political complexity relates to the people within a project which have potentially conflicting interests and difficult personalities (Geraldi et al., 2011; Maylor et al., 2008; Rolstadas et al., 2017). Socio-political complexity can be described by the attributes of the stakeholders' project priority, support, and agreement/fit. Dynamic complexity relates to changes which occur in a project. Dynamic complexity can be described by the attributes of adaptability, flexibility and alteration (Geraldi et al., 2011).

Complexity has been identified to not only deal with the project conditions but the perception of those conditions by the individual. Geraldi et al. (2011) performed an analysis on existing complexity measurements and identified that, in the end, project complexity is largely dependent on how an individual perceives and responds to the project conditions. In reflection they noted that the focus on the individual was not fully represented in existing complexity models. Tie and Bolluijt (2014) identified that the project team is usually responsible to manage project complexity. Based on this assumption, project complexity should not be solely defined based on the project conditions but should include the expertise of the individual or team executing the project. This is not a new idea, expertise has been regularly suggested to reduce complexity and improve performance (Arisholm et al., 2007; Buckland & Florian, 1991; Francis & Gunn, 2015; Qureshi & Kang, 2014). Based on the evident importance of expertise, some researchers have proposed to redefine project complexity by focusing on the expertise of the supplier or individual performing the project rather than the project conditions (Tie and Bolluijt, 2014; Vidal et al., 2011; Xia and Chan, 2012).

Research Question and Methodology

Kashiwagi (2018b) analyzed 19 different project complexity models and identified that researchers have built various methods to measure and define project complexity. Research has not yet found an explanation of how to reduce project complexity or its effect on project performance. Expertise has been identified as a potential solution (Kashiwagi, 2014); however, little is known about the extent of impact that expertise may have on project complexity.

The aim of our research is to develop a better understanding of the "effect" of expertise on ICT project complexity, measuring the "effect" through project performance. This research avenue may open new insights to handle project complexity and consequently improve project performance. In order to achieve our aim, our research questions (RQs) to be explored include:

- RQ1: What factors define project complexity?
- RQ2: What is the effect of the supplier's expertise on project complexity factors?
- RQ3: What challenges do experts and nonexperts have with respect to project complexity?

To meet our aim, a multi-method approach was taken using a literature review, survey and interview research. First, a literature review was conducted as a suitable method to identify relevant factors by which ICT project complexity can be defined (RQ1). The literature review identified publications which have already defined a unique list of project complexity factors. Secondly, through survey research and interviews (RQ2 and RQ3) the effect of the supplier's expertise on individual project complexity factors was measured using project performance as the scale to measure the "effect", see Figure 1.

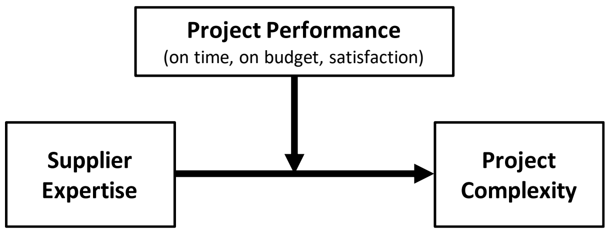

Figure 1: Research Approach

Research Approach

Literature Review Methodology

A literature review was performed, inclusive of four research databases (Engineering Village, Emerald Insight, ProQuest, Google Scholar). The terms "project complexity" + "complexity models" + "complexity factors" were used as keywords. The keywords were searched in each of the four databases within the first 500 publications. Publications were selected through the following process:

1. The publications had to be available in full text English.
2. The abstracts were reviewed and filtered based on the relation to project complexity factors.
3. The publications were fully reviewed and filtered based on the contribution of a unique list of project complexity factors.

The search resulted in the review of 2,000 publications' abstracts of which 19 publications were identified to relate to our research as they provided a unique listing of project complexity factors. When studying the 19 publications, we identified 623 project complexity factors. The publications' factors were refined through an exclusion/exclusion process. Factors included were directly related to the project including stakeholders and the scope of work. This corresponds to Azim et al. (2010), which identified the distinction between project complexity factors which relate to the people component of the project (stakeholders) and the product/service (scope) being delivered. Factors we excluded were contextual factors and ambiguous factors.
To analyze the factors, we built on Miles and Huberman (1994) by using a two-stage coding process to identify a broad range of "project complexity factors" as a proxy to measure ICT

project complexity. In the first stage of coding, the factors were clustered into two components of the project relating to the project stakeholders or project scope. After the coding of data within the designated components, the second stage involved coding the factors into subgroups based on the similarity of wording and content to create a coherency.

Survey Methodology

To answer our second research question, we conducted a survey (based on the factors identified in our literature review) and asked respondents to individually rate each of the project complexity factors' likelihood to be a cause of low project performance in two situations: (1) with an expert supplier and (2) with a nonexpert supplier. The survey included the responses of 97 practitioners involved in ICT projects. The scale ranged from 1 = Extremely Unlikely, 2 = Unlikely, 3 = Neutral, 4 = Likely, and 5 = Extremely Likely (See Figure 2). We then measured the effect of expertise on project complexity using project performance (on time, on budget and client satisfaction) as the scale of measurement.

In our analysis we first used the Wilcoxon signed-rank test to compare the expert scores with the nonexperts scores to determine if there was a significant difference between the effect on project complexity factors and expertise. We then compared the differential between the expert and nonexpert scores and the frequency of scores for the expert and nonexpert. Lastly, we examined the scores of the expert and nonexpert using the median, mode and mean to prioritize and compare factors.

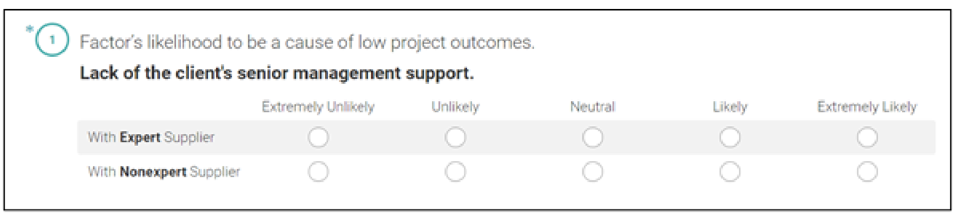

Figure 2: Survey Format

Interview Methodology

We conducted interviews with 15 practitioners involved in ICT projects to elaborate on the research findings from the survey research. Three criteria were used to determine eligibility inclusive of background (country, role and position), years of experience (minimum of five) and nonresponsive to the survey.

All interviews were conducted via video conferencing due to the geographical location of the participants in the period of October and November of 2018. Interviews varied from 25 to 50 minutes in length and we used a semi structured design. Applying a semi-structed interview method as a research instrument allowed us to elaborate on the findings through probing and discussion. The primary objective of the interviews was to elaborate on the research findings. Survey protocol instructions were sent to all interviewees prior to being interviewed. The protocol contains background and purpose of the research, instructions to the interviewee and the research findings which would be discussed.

Results and Findings

Literature Review Results

Based on our analysis and coding of the 623 factors, we derived a summarized list of 22 factors that influenced project complexity (see Table 1). These factors can be divided into two main components of the project, namely factors that relate to project stakeholders (8) and project scope (14). With the identification of the 22 project complexity factors it allows a more objective and standardized way to understand and quantify project complexity.

Table 1: Project Complexity Factors

#	Project Complexity Factor		Publications [out of 19]	
			#	% Frequency
1	Stakeholder	Lack of senior management support	11	57.9%
2		Appropriate authority and accountability	7	36.8%
3		The interaction and interdependence between stakeholders	13	68.4%
4		Multiple stakeholders	7	36.8%
5		Availability of the people and material due to sharing	12	63.2%
6		Conflict between stakeholders	8	42.1%
7		The stakeholder's technical knowledge and/or experience	6	31.6%
8		Geographical location of stakeholders	6	31.6%
9	Scope	Largeness of scope	12	63.2%
10		The client's project requirement is poorly defined	10	52.6%
11		The project comprises a diversity of tasks	7	36.8%
12		The size of the project budget	13	68.4%
13		The length of the project's duration	8	42.1%
14		The information uncertainty in the project	8	42.1%
15		A client with unrealistic goals	3	15.8%
16		The project's alignment with the business goals and interests	4	21.1%
17		The number of decisions to be made on the project	10	52.6%
18		The integration between technology	8	42.1%
19		The newness/novelty of the technology	5	26.3%
20		The technology is continuously changing	8	42.1%
21		The diversity of technology in the project	10	52.6%
22		Highly difficult technology	4	21.1%

Survey Results

The Wilcoxon signed-rank test showed that the expertise of the supplier elicits a statistically significant change in the likelihood to be a cause of low project outcomes in the case of all 22 project complexity factors (α of .05, p = 0.000), see appendix A for full tables results.
Upon further comparison of the respondents' scoring between the expert and nonexpert it was identified that expertise reduced the likelihood of poor performance caused by the project complexity factors. On average for each of the 22 individual project complexity factors 79% of respondents identified expertise to reduce performance issues caused by the project complexity factors, 19% identified no effect and 2% scored the expert more likely (see Table 2).

Table 2: Comparison of Expert and Nonexpert Scores

Measurement (average of the 22 factors)	**Average**	**Minimum**	**Maximum**
Expertise reduces performance issues caused by project complexity factor.	79%	55%	92%
Expertise has no effect on performance issues caused by project complexity factor.	19%	7%	44%
Expertise increases performance issues caused by project complexity factor.	2%	1%	7%

Analyzing the frequency of the respondents scoring it was identified that on average for each of the 22 factors, the expert would unlikely have poor project performance due to the project complexity factors (58% unlikely, 22% neutral, 20% likely). In contrast, it was identified that the nonexperts would likely have poor project performance due to the project complexity factors (81% likely, 16% neutral, 3% unlikely). (See Table 3, for full results see Appendix A).

Table 3: Frequency of Expert and Nonexpert Scores

Measurement (average of the 22 factors)	**With an Expert**	**With a Nonexpert**
Factors unlikely a cause of poor performance (Includes extremely unlikely and likely)	58%	3%
Neutral	22%	16%
Factor likely a cause of poor performance (Includes extremely likely and likely)	20%	81%

Lastly, we examined expert and nonexpert scores by the median, mode and mean (see Table 4). It was identified that the majority of expert scores were below three (unlikely a cause of low performance) while all of the nonexpert scores were above three (likely a cause of low performance). In further analyzing the expert scores, it was identified that 5 out of the 8 stakeholder related factors were within the top scores of the median, mode and/or mean. In contrast 2 of the 14 scope related factors were within the top scores for the mode and mean. In analysis of the nonexpert scores it was identified that the nonexpert struggles with all 22 project complexity factors (above neutral scoring), more so with scope factors than stakeholder factors.

For the nonexpert, in the case of stakeholder factors, six out of eight of the factors were within the lowest scores for the median, mode and/or mean.

Table 4: Prioritization of the Mean, Median and Mode

		Expert Scores			Nonexpert Scores		
Factor #		**Median**	**Mode**	**Mean**	**Median**	**Mode**	**Mean**
1	Project Stakeholder	3*	2	2.75*	5	5	4.43
2		2	2	2.19	4**	5	3.84**
3		2	2	2.27	4**	5	4.07
4		2	3*	2.42	4**	4**	4.19
5		3*	2	2.73*	4**	4**	4.28
6		3*	3*	2.88*	5	5	4.40
7		2	1	2.14	4**	5	4.22
8		2	3*	2.29	3**	3**	3.52**
9	Project Scope	2	2	2.26	5	5	4.50*
10		3*	2	2.71*	5	5	4.63*
11		2	2	2.07	4**	4**	3.88**
12		2	1	2.10	4**	4**	3.89**
13		2	2	2.27	4**	5	4.05
14		2	2	2.58	5	5	4.50*
15		3*	2	3.00*	5	5	4.64*
16		2	2	2.54	4**	5	3.96**
17		2	2	2.25	4**	5	4.33
18		2	1	2.06	4**	5	4.12
19		2	1	2.21	5	5	4.35
20		2	2	2.39	5	5	4.41
21		2	2	2.20	4**	5	4.25
22		2	2	2.25	5	5	4.46*

* Top five highest project complexity factors.

**Bottom five lowest project complexity factors.

Based on the survey findings the following four results were identified:

1. Expertise reduces project complexity: On average the 22 project complexity factors are less likely to cause poor project performance when working with an expert than a nonexpert. Using project performance as the scale to measure the effect of the supplier's expertise on project complexity, we conclude that expertise reduces project complexity.
2. Experts do not perceive ICT projects as complex while nonexperts perceive ICT projects as complex. It is reasonable to assume that the majority of respondents perceive that project complexity factors are likely to cause poor project performance with a nonexpert. We argue that if a supplier is unable to deliver a project on time, on budget and with a satisfied client that it recursively proves the project was perceived as complex. In contrast the opposite is arguably true, experts do not perceive ICT projects as complex.
3. Expert challenges that relate to project complexity factors correspond to project stakeholder factors. In general, project complexity factors do not seem likely to cause poor project performance with an expert. In prioritization of the project complexity factors, within the

context of an expert, we determined that the factors most likely to cause low project performance would be stakeholder related factors.

4. Nonexpert challenges that relate to project complexity factors correspond to project scope factors. In general, all 22 project complexity factors seem likely to cause poor project performance with nonexperts, but many of these same factors were not likely the cause of poor project performance with experts. In prioritization of the project complexity factors, within the context of a nonexpert, scope related factors were determined a greater issue to performance than stakeholder related factors.

Interview Results

The interviews were coded into three major themes including:

1. Experts understand the project.

The interviewees' identified that experts understand how to execute and manage the project. Past experience on similar projects was a primary method which allowed suppliers to gain their expertise. Results would suggest that being an expert is a project specific title and not a general overarching title. In contrast nonexperts were perceived to have the opposite effect, increasing the complexity of a project. The primary source of complexity was confirmed by interviewees to be dependent on the supplier's expertise not the project itself.

2. Limitations of an expert's influence.

The expert's ability to reduce project complexity and reduce project performance issues was perceived as limited. Interviewees identified that project stakeholder complexity factors are to a degree outside the control of the expert and dependent on client stakeholders. In contrast, scope related factors are within the expert's control, which explains why they are not a challenge for an expert. To a degree the expert can reduce the project complexity caused by stakeholder related factors due to their ability to simplify their actions and decisions to client stakeholders. Ultimately, the project complexity derives from the control the stakeholders have to disregard and not utilize the expert's counsel.

3. Nonexperts have a challenge with scope and stakeholder factors.

Nonexperts were confirmed to have challenges with both scope and stakeholder related factors. It is difficult to determine which one is of higher priority in terms of the effect it has on project complexity. Interviewees identified that nonexperts may place more importance on project scope complexity factors due to the requirement and chronology of a project. Nonexperts main focus resides in completing the project scope, hence stakeholder related factors may not be encountered till later in the project. Lastly, nonexperts, due to their lack of knowledge, may increase the need for the client to have personnel with the technical knowledge and/or experience.

Substantiation and support of these three themes are described in the preceding subsections.

Experts Understand the Project

The interviews identified that a key characteristic to an expert is that they understand the project. The understanding allows the expert to know how to manage and execute the project and have sufficient capability to properly do it. Experts were identified to understand the project based on past experience. The experience is gained due to performing similar projects, lessons learned and repeated actions.

'I would say an expert would always see the project as simple because they have done it, they know what it takes to do it, and they know where the pitfalls are, so they have already avoided it a bunch of times and it's so easy to avoid it again' (Interviewee R1). 'I think the things they view as complex are things, they have less experience... If they did have more similar situations that weren't new, by in large it would not be complex.' (Interviewee R4).

One interviewee gave an example of cycling in the city of Amsterdam to explain his logic. If you cycled every day you find it normal and noncomplex. In contrast if you are visitor and rent a bicycle for the first time and ride around Amsterdam, the ride would be quite complex. Similarly, the interviewee referred his example to his job description.

'I don't think I do a difficult job. But our clients still hire our company to help them with these projects because they say, we need help because it is very complex. And we say it's everyday work, this is what we are good at and this is why we come in and help' (Interviewee R10).

Interviewees compared the contrast between experts and nonexperts within the same field or project to emphasize the difference between an expert and nonexpert. The nonexpert was identified to have the opposite effect of an expert. Nonexperts who don't understand how to manage and execute a project increase the effect of complexity because they add to the degree and possibly cause the complexity.

'If I were to go in and say this is what you are going to do, and this is how you are going to do it, I don't actually understand all the backend relational complexities that could be there, so then I'm making it inherently more complicated… I'm adding the complexity because I don't know what I'm talking about.' (Interviewee R3).

One interviewee gave an example of an ICT project which required the creation of a website. The project initially failed, costing the client over two million Euros. A second supplier was hired shortly after, who successfully built the project in three months for 200,000 Euros. The interviewee identified the difference between the two situations. In the first situation the client, was telling a nonexpert how to build the website. The second situation involved hiring an expert and letting the expert tell the client how to build the website.

'This is a good example of first spending years and millions of EUROs with a nonexpert on a project and making it very seemingly complex. Then moving it around, leaving the experts telling us how to build it.' (Interviewee R15).

Limitation of an Expert's Influence

Experts were identified to perceive projects as noncomplex and be able to reduce the effect of project complexity on project outcomes. However, the interviews identified that there were limitations to the expert's influence. The stakeholder aspects were identified as a challenge for an expert because to an extent, they are outside of the expert's control.

'That's the thing when a project becomes bigger, the number of stakeholders and the number of people involved becomes bigger. So, on the project content part, size doesn't really matter… what becomes complex is more people trying to influence or become involved.' (Interviewee R13). 'The larger the scale, the larger the number stakeholders there will be, which are things outside the control of even the expert. However, depending on the maturity of the expertise of the expert there is a scale by which this will start.' (Interviewee R14).

This is not to say that an expert has absolutely no control, but the amount is limited. Experts, due to their expertise, are able to reduce the effect of project complexity on project performance. Their minimizing effect is attributed to their ability to justify and explain their actions in laymen's terms. Interviewees suggest that the greater the expertise, the greater capacity to handle client stakeholder issues.

'Now that's a mark of a software expert. They should be able to overcome even the limitations of the client. If I have a really bad subject matter expert in one of my groups, the expert should still be able to overcome that.' (Interviewee R2). 'Well I consider expertise also good at helping clients to come along and to see. Unfortunately, they don't have complete control no matter how good you are... I do think true experts have a way of helping the competent feeling comfortable with the decisions they are making and the impact of decisions they are making. Part of being an expert is helping them realize this. I think you can mitigate a lot of it but not all of it.' (Interviewee R6).

The stakeholder factor may still be an issue if the stakeholders are unwilling to listen or unwilling to change their direction. Regardless of how well it is explained or presented, since the stakeholder is outside of the supplier's control, the end decision is out of the supplier's hands. An interviewee explained a major reason of resistance is that the client often feels attacked and does not want to admit to their internal organization that they have made a mistake. Another interviewee described it can be more than just shame but active resistance due to a power struggle.

'…we have the experts from the client side (the IT staff) and the experts from the IT provider. I have seen challenges for the provider because the IT staff think they know it better than the IT provider... that's a struggle for the expert.' (Respondent R9).

Nonexperts have a challenge with Scope and Stakeholder Factors

The interviews identified that the nonexpert has a challenge with scope related factors. Since nonexperts do not understand a project, they perceive it as complex and do not have clear vision of what to do. Nonexperts will encounter issues, many of which are self-inflicted mistakes, that an expert would never have to deal with.

'The challenges of a nonexpert is not being able to oversee the different processes of the project right. If you don't oversee the priorities, risk and time then each one of those would lead to inefficiency. (Interviewee 14). 'If you're a nonexpert you are bound to be making mistakes along the way. It is going to exacerbate; it's going to create bad feeling with the client. They are going to feel like they are paying you for expertise and they are not getting it and you are going to run into a lot of issues that an expert would not have to make' (Interviewee R6).

The challenge with scope related factors does not mean the stakeholder factors are not a challenge for the nonexpert. The interviewees indicated that the question is a matter of priority of challenges. The nonexperts will first focus on delivering the project scope. One interviewee explained the scope related factors are prioritized higher because it is more acceptable to have a poor or broken product or service than to not have a product at all.

'The thing is when you are a nonexpert you are trying to struggle so much with the technology that you are totally forgetting the client aspects…' (Interviewee R11). That is true because they don't get to the stage of the client. The client challenges are always there. It's just that for a nonexpert the project scope complexity dwarfs the client aspects. And so, it seems like an immaterial thing because that's a problem but it's not as a problem as the scope content factors' (Interviewee R5).

Interviewees identified nonexpert supplier's priority with the project scope may be related to the chronologically of an expert's activities. A nonexpert is prone to jump right into working on the scope of the project. They are unable to see potential risks or mistakes which they will encounter nor the stakeholder issues that may arise. An interviewee gave an example of a client with too small of a budget or an unrealistic goal. An expert would be able to identify this problem early on and encounter possible stakeholder pushback. In contrast the nonexpert would only focus on working on the project scope and may never get to the stakeholder issues due to their inability to finish the project scope.

'If a client defines a certain scope, an expert supplier will understand if that the scope is too big, cannot be handled or cannot be done within the given timeframe. An expert would see this and warn the client, the nonexpert doesn't even know it.' (Interviewee R15).

The nonexpert may eventually have to deal with the stakeholder factors. If this occurs, the nonexpert will have a more difficult time with stakeholder factors than an expert. Interviewees explain that experts have their expertise to mitigate stakeholder factors. Since experts understand the project they can justify and reason with the stakeholder. Nonexperts on the other hand have no method to mitigate stakeholder factors. This will result in the nonexpert being outranked by a stakeholder due to their inability to explain their recommendations and then be forced to perform whatever actions the stakeholder dictates.

'Nonexpert will have an even harder time I think with client aspects. They will be blown right away by the IT staff of the buyer. He has from the beginning a difficult time. I certainly think a nonexpert is not successful in this business.' (Interviewee R9).

The interviewees further identify that nonexpert suppliers eventually place the requirement of expertise on the stakeholders. In cases with a nonexpert, someone has to manage the tasks and actions to complete the project. If the supplier is a nonexpert, they will require the stakeholders to direct them on what to do. One interviewee explains the danger of this, as the accountability would then lie with the stakeholder. In cases of project failure, the supplier would be able to blame the stakeholders, as they were the entity responsible for every decision.

'And at the end of it if there is an issue or failure, at that point they [the supplier] say well, we tried to go down this root and you [client stakeholders] wouldn't let us, so we just did exactly what you told us to do and it didn't work but we did exactly what you told us to do.' (Interviewee R3).

Conclusion

The study's aim was to better understand the "effect" of expertise on ICT project complexity, measuring the "effect" through project performance. The three research questions investigated include: (RQ1) What factors define project complexity? (RQ2) What is the effect of the supplier's expertise on project complexity factors? And (RQ3) What challenges do experts and nonexperts have with respect to project complexity? The first research question identified 22 unique project complexity factors through literature review. The second and third research questions were answered through survey and interviews. The studies identified that (1) expertise reduces project complexity, (2) experts do not perceive ICT projects as complex while nonexperts perceive ICT projects as complex, (3) experts' challenges that relate to project complexity factors correspond to project stakeholder factors due to stakeholders, to an extent, being outside the control of the expert. (4) nonexpert's challenges that relate to project complexity factors correspond to project scope factors.

Discussion and Future Research

This research identified that the role of an expert (expertise) has the potential to reduce project complexity. In contrast, based on our results from this paper, the nonexpert is unable to reduce project complexity and may be the source of complexity. Existing models such as Azim et al. (2010), Tatikonda and Rosenthal (2000) and Florciel et al. (2015) measure project complexity factors which describe the project conditions inclusive of the technology, size, stakeholders, interrelations, and interdependence. Our findings from the current study suggest the need to expand the modelling of complexity to include project performance. We argue that factors which do not affect project performance should be excluded from the definition of project complexity as they do not align with the current industry practical use of the word complexity. The new definition of complexity should be connected to project performance as its primary indicator of complexity.

Literature suggests that expertise is a key component to handling and reducing project complexity. To the best of our knowledge, ICT project complexity models have not been studied by using the lens of expertise. Literature, such as Bakhshi et al. (2016), has addressed project team factors which may pertain to expertise, including competencies, knowledge, experience, education, and training; however, these models do not focus on expertise or place a priority on factors which may pertain to expertise (Abdou et al., 2016; Bakhshi et al., 2016; Qing-hua et al., 2012; Xia & Chan 2012). Based on our findings from this paper, we claim that existing project complexity models should be adjusted to have the primary focus on measuring expertise. The findings also reveal that project stakeholders are the greatest challenge for expert suppliers. Project stakeholders have been identified as a great risk to experts as they are outside of the control of the expert. Project complexity models should not only focus on identifying the expertise of the supplier but also stakeholder factors which may impede the utilization of the supplier's expertise.

The theoretical modelling of existing project complexity models can be enhanced by incorporating (1) the effect that project complexity factors have on project performance, (2) the supplier's expertise and, (3) stakeholder factors which impede the utilization of the supplier's expertise. For example, Xia and Lee (2004) introduce a model to measure the complexity within Information System Development Projects (ISDP) through 20 factors. In analyzing the 20 factors, 11 (55%) are related to the project scope, six (30%) are related to the project stakeholders, and two (10%) are related to the expertise of the personnel executing the project. Based on our research findings from this paper, the 11 factors related to the project scope may measure a traditional definition of complexity however, the factors (which comprise 55% of the cited factors) would be of minimal effect to project performance when an expert supplier is present. This model could be adjusted by emphasizing factors which measure the expertise of the supplier executing the project and the stakeholder factors which impede the supplier from executing the project.

We argue that future project complexity models need to have a primary focus on the expertise of the supplier and incorporate measuring project complexity in terms of the effect it has on project performance. The refocusing of project complexity models has the potential to improve their accuracy and effectiveness.

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Appendix

Table 5: Wilcoxon Signed Rank Test Results for Factors 1 to 8

Wilcoxon Signed Rank Test	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Sum of positive ranks	29	254	71.5	12.5	10	11.5	64.5	8.5
Sum of negative ranks	3292	3401	3249.5	2913.5	2405	2334.5	3505.5	1476.5
N (excludes tie rankings)	**81**	**85**	**81**	**76**	**69**	**68**	**84**	**54**
Expected value	1661	1828	1661	1463	1208	1173	1785	743
Standard deviation	129	168	157	146	99	120	175	77
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 6: Wilcoxon Signed Rank Test Results for Factors 9 to 16

Wilcoxon Signed Rank	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Sum of positive ranks	12	51.5	51.5	10.5	14.5	12	12	105.5
Sum of negative ranks	4083	3434.5	3188.5	2690.5	3225.5	3474	2616	2309.5
N (excludes tie rankings)	**90**	**83**	**80**	**73**	**80**	**83**	**72**	**69**
Expected value	2048	1743	1620	1351	1620	1743	1314	1208
Standard deviation	196	170	154	141	148	160	135	90
p-value (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 7: Wilcoxon Signed Rank Test Results for Factors 17 to 22

Wilcoxon Signed Rank Test	**17**	**18**	**19**	**20**	**21**	**22**
Sum of positive ranks	49.5	14	9	11.5	13	9
Sum of negative ranks	3691.5	3641	3231	3391.5	3390	3561
N (excludes tie rankings)	**86**	**85**	**80**	**82**	**82**	**84**
Expected value	1871	1828	1620	1702	1702	1785
Standard deviation	178	173	163	171	168	176
p-value (two-tailed)	0.000	0.000	0.000	0.000	0.000	0.000

Table 8: Respondent Frequency of Score Differential (Difference: Expert – Nonexpert)

Difference	**Min**	**Max**	**Avg**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Negative Differential	55%	92%	79%	81%	80%	81%	77%	70%	69%	85%	55%	92%	84%	80%
No Differential	7%	44%	19%	16%	12%	16%	22%	29%	30%	13%	44%	7%	14%	18%
Positive Differential	1%	7%	2%	2%	7%	2%	1%	1%	1%	2%	1%	1%	2%	2%
Difference				**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Negative Differential				74%	81%	85%	73%	67%	87%	87%	81%	84%	84%	86%
No Differential				25%	18%	14%	26%	29%	11%	12%	18%	15%	15%	13%
Positive Differential				1%	1%	1%	1%	4%	2%	1%	1%	1%	1%	1%

Table 9: Frequency of Scoring in Expert Situation

Expert Situation	**Avg**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Extremely Unlikely	25%	15%	34%	23%	23%	18%	13%	34%	27%	26%	20%	30%
Unlikely	33%	32%	37%	40%	30%	31%	26%	33%	26%	40%	30%	40%
Neutral	22%	20%	7%	26%	31%	19%	28%	19%	39%	16%	18%	23%
Likely	16%	28%	20%	10%	15%	27%	26%	13%	8%	18%	26%	7%
Extremely Likely	3%	5%	2%	1%	1%	6%	7%	1%	0%	0%	7%	0%
Expert Situation		**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Extremely Unlikely		32%	26%	16%	13%	25%	30%	37%	32%	24%	30%	29%
Unlikely		32%	37%	35%	31%	29%	33%	32%	32%	34%	33%	38%
Neutral		30%	22%	25%	12%	22%	23%	19%	24%	24%	26%	14%
Likely		6%	15%	22%	29%	18%	11%	12%	8%	16%	10%	16%
Extremely Likely		0%	0%	2%	14%	7%	3%	0%	4%	2%	1%	2%

Table 10: Frequency of Scoring in Nonexpert Situation

Nonexpert Situation	**Avg**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Extremely Unlikely	1%	1%	4%	0%	0%	0%	0%	1%	2%	0%	1%	0%
Unlikely	3%	1%	14%	2%	0%	0%	0%	4%	8%	2%	0%	5%
Neutral	16%	5%	11%	27%	18%	12%	11%	15%	44%	4%	5%	25%
Likely	35%	39%	34%	33%	46%	47%	37%	31%	27%	36%	23%	47%
Extremely Likely	45%	54%	36%	38%	36%	40%	52%	48%	19%	58%	71%	23%
Nonexpert Situation		**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Extremely Unlikely		1%	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%
Unlikely		4%	2%	0%	0%	5%	0%	3%	3%	1%	1%	0%
Neutral		31%	27%	6%	3%	26%	15%	22%	12%	14%	15%	8%
Likely		33%	35%	38%	30%	33%	36%	31%	31%	27%	41%	37%
Extremely Likely		31%	36%	56%	67%	35%	48%	43%	54%	58%	42%	55%

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