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Uncovering Value in Knowledge-based Services: Monetizing Latent Service Quality Indicators for Source Selection

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Abstract

This paper provides a summary of doctoral research conducted from 2017 to 2020 exploring the perceived quality and value constructs of business-to-government (B2G) knowledge-based services (KBS; Finkenstadt, 2020). The research uses factor analytic techniques to explore the best latent measures of perceived service quality for KBS as precursors to perceived value in a public procurement context. KBS perceived quality is found to be a second-order factor construct that influences customer perceptions of value in B2G exchanges. This is a unique construct consisting of first-order factors related to employee capability, ability to provide intelligent solutions, employee dependability and the KBS firm's understanding of customer organizational requirements. This construct assists B2G customers in mitigating adverse selection and moral hazard risks with better information. The research provides a way to monetize the trade-off between price and quality using a perceived service quality scale for KBS and a choice-based conjoint methodology in a Department of Defense setting. This increases the possibility of improving service value and decision speed. The paper extends the literature on perceived service quality, value, and willingness to pay for B2G KBS exchanges.

Introduction

There has been a call for the defense acquisition workforce to provide a clear definition of "best value" to industry for some time now (Kendall, 2015). If industry doesn't understand what best value means to the customer or procuring agency, then how can they provide the best possible offer? In turn, how can the government ensure it is getting value for money? This paper summarizes three years of dissertation research aimed at defining the elusive perceived quality and perceived value constructs in order to improve acquisition efficiency and effectiveness for federal agencies. Two axioms of procuring activities guide this research. First, the three primary objectives of public procurement are transparency, value for money, and meeting agency requirements (Gilbert, Schapper, & Veiga-Malta, 2009). These objectives are interoperable and dependent on one another. Secondly, the ability to procure services effectively and efficiently is desirable and in the public's interest (Gilbert et al., 2009). This paper explores the following research questions:

1) How is KBS defined for B2G markets?
2) How does perceived service quality manifest as a construct in B2G KBS?
3) What are the most efficient and effective indicators of perceived KBS quality that impact perceptions of value?
4) Can these latent indicators be monetized for operational use in making best value determinations for KBS?

This paper explains the results of two studies conducted from 2017 to 2020 (Finkenstadt, 2020). The first study used a mixed methods approach to investigate existing service performance measures, develop a conceptual model for perceived service quality and value, and build a psychometrically sound service quality scale that considers perceived levels of service delivery to aid federal agencies in conducting source selections and post-award

contract management of KBS firms (Finkenstadt, 2020). This analysis informed the development of an optimal set of perceived quality indicators for KBS. In the second study, researchers used choice-based conjoint (CBC) methods on a sample of 631 government contracting personnel to monetize the various levels of perceived KBS quality factors (Finkenstadt & Hawkins, 2016). This monetization allows for an improved operationalization of an established but underutilized source selection method known as Quality-infused Pricing (QIP©).

Nature of Services

Services account for over 45% of gross domestic product and 66% of personal consumption in the United States (U.S. Department of Commerce, 2017). The percentage spent on services is even greater in the nation's defense spending, making them a keen area of focus (Air Force Installation Contracting Center, n.d.). Services have been defined as "the application of specialized competences (knowledge & skills) through deeds, processes, & performances for the benefits of another entity or the entity itself" (Vargo & Lusch, 2004a, p. 2). They have been called complex, heterogeneous, and intangible (Apte et al., 2006) as well as perishable and inseparable (Vargo & Lusch, 2004b). The Bureau of Economic Analysis defines them as "products, such as medical care and transportation, that cannot be stored and that generally are consumed at the place and time of their purchase" (U.S. Department of Commerce, 2017, p. A6). These characteristics makes it hard to nail down a generalizable definition that extends into difficulties defining service quality (Hawkins et al., 2015). In the absence of clear, objective measures, perceptions can provide reflective indicators of quality.

Knowledge-based Services

KBS are the largest area of spend in the DoD service portfolio (Defense Procurement and Acquisition Policy, n.d.). Air Force Instruction (AFI) 63-138, Paragraph 1.2.1.3 states that KBS are those defined in DoD Instruction (DODI) 5000.74. The AFI states that this includes, but is not limited to, advisory and assistance services to support research and development, construction, architect engineering, utility services, federally funded research development center contracts, or foreign military sales (Secretary of the Air Force, 2017). The DODI points to the Under Secretary of Defense for Acquisition, Technology and Logistics memorandum, *Taxonomy for the Acquisition of Services and Supplies & Equipment*, dated August 27, 2012. The trail of Air Force and DoD cross referencing is somewhat winding but ends at this point. Through an extensive review of the literature, this author defines KBS as *those services in which the primary medium of exchange is a transfer of expert advice, knowledge, processes, or information. Such services are generally low in capital intensity and high in knowledge intensity.* As knowledge-intensity leads to a more service-centric view of quality, the use of perceived quality scales becomes more necessary and effective as a possible measure of value. If agencies misunderstand the use of perceived quality, it can aggravate an already tenuous best value determination process.

Source Selection Methods and Past Performance Measurement Issues

Best value source selections in government acquisition range from lowest price technically acceptable (LPTA) to subjective, or "full", trade-off (full TO). The newest form of source selection published by the DoD is the value adjusted total evaluated price (VATEP) method. This method assigns value to performance improvements above a threshold (minimum) but not to exceed an objective (maximum). Source selection methods have been met with scrutiny over the past few years for leading to low quality and value (LPTA) and as being slow and unclear in terms of prioritization and relative importance of evaluation factors (i.e., full TO)

(Watson, 2015; Landale et al., 2017). At the same time, the current Contractor Performance Assessment Reporting System (CPARS) past performance rating system has been criticized for being untimely, incomplete, and inaccurate (Blott et al., 2015; CPARS, 2015; GAO, 2014; Hutton & Solis, 2009). Issues with past performance reporting compound the difficulty in making discerning best value trade-offs for all acquisitions.

The author introduced a fourth form of source selection in 2015 known as the quality-infused price (QIP©) methodology (Finkenstadt, 2015; Finkenstadt & Hawkins, 2016). This form of source selection was created to find an optimum point within the three primary public procurement objectives and the ability to use latent measures of quality (see Figure 1.)

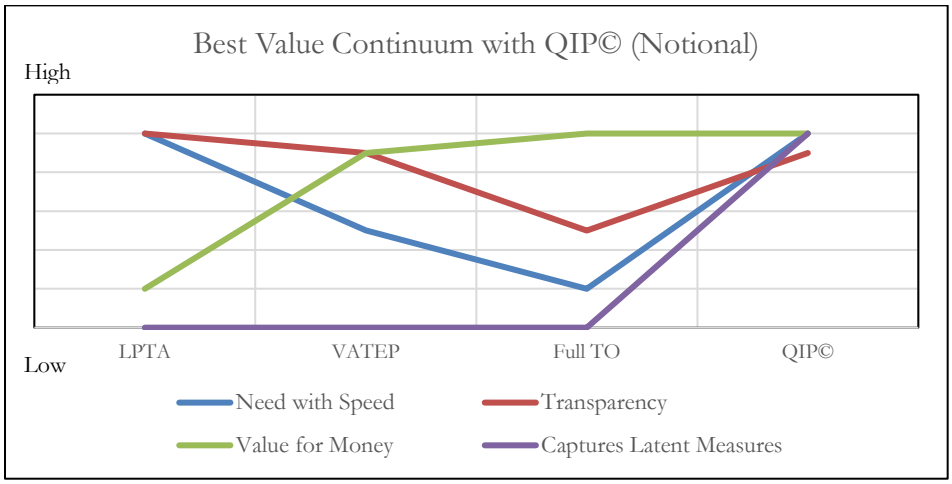

Figure 1: Source Selection Method Comparison Chart

Figure 1 is completely notional but demonstrates an anecdotal assessment of each source selection method relative to public procurement objectives. For example, LPTA is expected to be very efficient (i.e., need with speed) and transparent. The pass/fail evaluations for technical acceptability, coupled with lowest price preference makes the evaluation method very transparent and very fast relative to others. However, there is a chance that value for money is exceedingly low in cases where things like latent quality measures would be more discriminating. LPTA does not capture latent quality measures at all. VATEP could improve value for money compared to LPTA. VATEP is more transparent than full TO but comes at a cost to value for money and need with speed if the thresholds and objectives are not adequately understood. Full TO allows a team to maximize value for money, but the relative subjectivity of the process undermines transparency and need with speed in cases where the teams do not clearly express their evaluation methods and/or follow them (i.e., increased protest risk or adverse selection). None of these methods allows for the use of latent quality indicators in their evaluations. QIP© is an optimal process for meeting these four objectives in portfolios like KBS where latent quality measures matter as much or more than objective measures. The rating scale and monetization process is transparent. QIP© is not as transparent as picking the lowest price after surviving a pass/fail technical evaluation (LPTA), but it is much more transparent for firms than full TO or VATEP. It shows firms exactly how past performance service quality can impact the monetized value of their future offers. Now that this research has established the perceived KBS quality scale and trade-offs to be used, the process is very efficient (i.e., need with speed) and the value determination is essentially baked into the performance ratings.

QIP© suggests the use of performance ratings using a psychometrically sound scale of quality perceptions to assign price trade-off percentages to specific ratings. For instance, a firm rated a 7 on a 7-point Likert scale for perceived quality factors would receive a value amount to be traded relative to the comparative firm who might be rated a 5 on a 7-point scale. An example is offered later in this paper. This eases the evaluation burden for source selection teams while increasing transparency to the public by allowing the firm to know what sort of performance indicators may affect their evaluated price. Both evaluation complexity and transparency have been noted as issues with LPTA and full TO source selections respectively. Firms can better position their offers based on previous performance ratings. Published quality reviews have been shown to affect abnormal returns and firm valuation in products and may have the same effect in B2G KBS (Tellis & Johnson, 2007). QIP© also allows procurement teams to encourage stronger post-award performance from firms by making it known that such ratings will be used in the future to adjust price evaluations for additional contracts.

This method has been successfully employed by the U.S. Army and General Services Administration (GSA) to date. QIP© has also been found to be a useful measure of service quality, create cooperative industry participation, encourage fewer yet higher quality proposals for evaluation (i.e., reduced adverse selection risk with greater efficiency), and increase the price competitiveness for the highest quality–ranked offerors (Finkenstadt & Hawkins, 2016). The method has survived protests as well (see GAO Decision B-414387 and B-414387.2; General Dynamics Information Technology, 2017).

Below is a testimony from an acquisition chief at GSA that utilized the QIP© method on over $1 billion in KBS acquisitions:

> *Yes, QIP reduced our PALTs. Both in the evaluative phase and overall.*
> *For example, fighting protest is a new normal in acquisition (especially on large competitive acquisitions). QIP turned out to be a very valuable tool in all our GAO protest defenses. ...QIP produces a definitive winner.*

As mentioned, a robust methodology was utilized to arrive at the correct perceived KBS quality indicators and trade-offs. The methodology and results from study 1 are offered next, followed by those in study 2.

Study 1 Methodology

The methodology employed in study 1 was a mixed methods approach of literature review and qualitative, psychometric, and structural equation modeling. The following section provides details to this approach consisting of an expert panel, focus groups, pretest survey, final survey, factor analysis, item-response theory (IRT) scale refinement, structural equation modeling, and correlate exploration techniques. Literature review, expert panel, focus group, and interview information are detailed further within the author's dissertation but are not included here for brevity. We next detail the survey development portion of the methodology.

Survey Pretest

The pretest survey was constructed and reviewed by the research team and the United States Air Force Survey Office to eliminate sources of method bias and fulfill human research ethics requirements for the Air Force (Doty & Glick, 1998; Fiske & Kinder, 1981; Krosnick, 1991, 1999). The pretest survey consisted of a battery of 76 items using Qualtrics software.

The pretest survey was sent to 194 members of the Air Force acquisition community, including both military and civilian personnel, during the summer of 2018. Of the 194 personnel surveyed, 118 personnel completed the survey (60.8% response rate). However, of those 118

completed surveys, only 100 had prior experience with KBS. The respondents' demographic information is summarized in Table 1 for both the pretest and final surveys .

Table 1: Survey Statistics

	Pretest	Final-Wave 1	Final-Wave 2	Final-Summary
Total Respondents(n)	118	868	279	1147
n of public workers	109	865	279	1144
n of private workers	9	3	0	3
n of respondents with KBS experience	100	546	225	771*
Male	41%	55%	79%	62%
Female	59%	45%	21%	38%
Average age range	35-44	35-54	35-44	-
Primary role	Contracting Officer/ Manager/Administrator	Contracting Officer/ Manager/Administrator	Program Manager and Engineer	-
Average years' experience with KBS	11–15 years	11–20 years	6–15 years	-
Primary contracting and PM DAWIA levels	49.23% Contracting III, 23.08% PM I	46.03% Contracting III, 20.90% PM I	2.26% Contracting I, 34.82% PM II	-
Top of mind KBS	Not asked	Advisory and Assistance Services	Advisory and Assistance Services	Advisory and Assistance Services

*This n is prior to removal of those with missing data. Final n used in analysis was 639.

Final Survey

The final survey consisted of 39 total survey items related to a conceptual model of B2G KBS detailed in the author's dissertation. This included 20 perceived KBS quality items. This survey was again reviewed by the Air Force Survey Office and approved for release and endorsed by the Air Force's deputy assistant secretary for acquisition (Contracting) and the deputy assistant secretary for acquisition integration. The survey was released in two waves to allow for cross validation as well as to ensure a comprehensive customer set was represented in the data. Response rates are impacted by the fact that the focal group, personnel with experience in knowledge-based services contracts, is not tracked by the Air Force, and we must rely on self-reporting to identify this experience in our sample. Both pre- and final surveys were anonymous and voluntary.

The first wave ran from October 3, 2018, to November 3, 2018. This wave was sent to a pool of 7,980 Air Force contracting personnel. The response rate was 13.57% (1,083 respondents). Of this group, 870 personnel completed the survey entirely, and of this subset 445 respondents had requisite experience with KBS services and no missing data in their survey responses. The second wave ran from November 1, 2018, to November 22, 2018. This wave was sent to a pool of 24,664 Air Force program management and engineering personnel. The response rate was low at 1.4% (350 respondents). Of this group, 270 personnel completed the survey entirely, and of this subset 194 respondents had requisite experience with KBS services and no missing data in their survey responses. Between the two waves, we were able to obtain 639 responses that had no missing data and requisite experience with knowledge-based services. This number represents a 16.38 respondent-to-item ratio, more than adequate for factor analysis (Steenkamp, 2018). The pool of respondents is representative of the B2G customers who evaluate KBS quality and value during the pre- and post-award phases of KBS contract management.

Study 1 Findings

The primary construct analyzed was perceived quality. This factor was labeled "KBSQual" and initially consisted of 20 items binned into preconceived categories of empathy (EM), expert advice (EA), personnel consistency (PC), reliability (RL), and reassurance (RS) for coding purposes. Confirmatory factor analysis was conducted on the scale assuming a second-order factor model similar to the most widely used perceived service quality scale, SERVQUAL (Parasuraman et al.,1988). These first order factors consisted of understanding the customer (2-indicators), employee capability (2-indicators), intelligence/knowledge of the employees (3-indicators) and employee dependability/reliability (2-indicators).

Table 2 demonstrates that model fit for the second-order factor model is excellent and all item loadings are strong. This result supports that KBS perceived quality is a unique, multi-dimensional construct.

Table 2: Loadings and Fit of Second-order KBS Perceived Quality Model

	RMSEA	CFI	TLI	SRMR				
Second Order Factor Model	0.036	0.993	0.99	0.011	Loading on Second Factor*			
Understanding the Customer	**Item Code**	**Loading**	**S.E.**	**Two-tailed p-value**	**KBS QUALITY**			
1. The firm's employees were knowledgeable about our mission/goals.	EM1	0.918	0.019	0.000	0.791316			
2. The firm's employees were knowledgeable about our processes and procedures.	EM2	0.922	0.015	0.000	0.794764			
Capability								
11. The firm's employees were highly capable.	EA11	0.939	0.011	0.000		0.905196		
2. The firm's employees provided a positive contribution to our team.	EA2	0.947	0.009	0.000		0.912908		
Intelligence/Knowledge								
7. The firm's employees provided intelligent solutions.	EA7	0.943	0.012	0.000			0.891135	
8. The firm's employees provided expert advice.	EA8	0.979	0.005	0.000			0.925155	
9. The firm's employees filled a knowledge gap in our organization.	EA9	0.845	0.02	0.000			0.798525	
Dependability/Reliability								
3. The firm's employees were dependable.	RL3	0.949	0.012	0.000				0.868335
4. The firm provided its services at the time it promised to do so.	RL4	0.838	0.022	0.000				0.76677
KBS QUALITY								
Understanding the Customer	UNDER	0.862	0.023	0.000				
Capability	CAPS	0.964	0.01	0.000	*Calculated as the product of item and factor loadings. I.e. EM1 loading on KBS Quality is = 0.939*0.862 = 0.791316			
Dependability/Reliability	DEP	0.915	0.02	0.000				
Intelligence/Knowledge	INTEL	0.945	0.01	0.000				

Scale Reduction with Item Response Theory

Although the model fit was good, it was necessary to pare down the first-order factors to a single item for use by agencies. Agencies require a perceived quality scale for KBS that is effective (i.e., reliably measures the intended latent constructs) yet efficient (can measure these latent constructs with minimal items). Also, with our second essay in mind, we needed to reduce the items per first-order factor to one each. The second essay of this dissertation utilizes choice-based conjoint (CBC) methods that treat each first-order factor as a single attribute. Item Response Theory (IRT) allowed us to find the single item that best represents these latent constructs as attributes. The key in this review is to discern if there are redundancies in the scale, or regions of KBSQual scores where no discriminant information is provided by the additional item, or, in our case, the item that represents the most discriminant information. Visually this manifests in curves that fall over the area of other item information curves. This resulted in single items for our four first-order factors of understanding (EM1), capability (EA11), intelligence/knowledge (EA7) and dependability/reliability (RL3).

We were also able to look at correlations and mean scores for this perceived KBS quality construct across an array of demographic information. We find that, contrary to literature, years of experience do not impact mean quality ratings. We find that the most telling difference in perceived KBS quality ratings comes from the respondent having achieved DAWIA Contracting Level 3 certification. These personnel exhibit statistically lower mean scores on

perceived KBS quality than those without the certification. This may indicate that fully certified contracting personnel may be the most discerning gate keepers for this scoring system.

Study 2 Methodology

In study 2, we took the four indicators from KBSQual, derived using IRT, and employed them to examine attribute monetization through conjoint analysis, providing empirical evidence for the range of weights attributable to price and perceived quality attributes for B2G KBS. We also provided a process for developing perceived quality and value measures that can be monetized through CBC responses—what we consider an uncovering of value through conjoint analysis monetization techniques. To increase the saliency of our respondent's choice condition, we needed to create an environment that reflects what public procurement agents face when determining how much additional quality to pay for in a selection of KBS firms. This condition was necessary to examine the monetary value a buyer places on specific past performance of perceived quality attributes. Such an environment requires a degree of realism. To evoke a sense of realism, we constructed a conjoint scenario in which the complex decisions necessary to arrive at a need for a price-performance trade-off were satisfied a priori. Further, the adjectival levels of attributes had to be easily translatable to trade-off evaluation adjectival ratings found in real-world B2G source selections. The sample of respondents had to represent personnel who would reasonably be expected to make such trade-off decisions for the government (e.g., contracting officers or program managers). We were able to satisfy these conditions.

Discrete Choice Method: Choice-based Conjoint

Various forms of conjoint analysis exist. We elected to use choice-based conjoint (CBC) analysis with Hierarchical Bayesian estimation (Orme, 2014; 2000). This method allowed us to reproduce a more realistic choice scenario as well as to simulate respondent choices without the independence from irrelevant alternative issues found in logit estimations on aggregate data (Orme, 2000). Choice-based conjoint (CBC) provided a greater degree of realism compared to other forms of market research techniques for customer choice in the past (Louviere & Woodworth, 1983). CBC produces the utility of each price and non-price attribute for each customer and the aggregate sample. We used these utilities to calculate willingness to pay and simulated changes in predicted share preferences for any combination of our attributes as offers. It allowed us to calculate the relative importance of each attribute on choice relative to all other attributes. In CBC analysis, importance represents the "maximum impact an attribute can exert upon … choice" (Orme, 2014, p. 192).

Attributes, Levels, and Willingness to Pay Measures

Our CBC offer profiles consist of four perceived service quality attributes and price. There were four levels for perceived service quality and five levels for price. We were able to create this parsimonious leveling by priming the respondents to consider the choices made when price and past performance are the only pertinent factors in the trade-off analysis. Using Sawtooth® Choice Based Conjoint Software we constructed 22 choice profiles. Each choice profile offered three randomly structured attribute profiles and a fourth option for opting out of the choice set, described as "None-I would not choose any of these."

We elected to use the four items from the IRT-reduced scale in study 1 related to employee capability, intelligent solutions, employee dependability, and the firm's understanding of customer organizational requirements (see Table 3.)

Table 3: Choice-based Conjoint Quality Attribute Rating Descriptions

Attribute	Description to Respondents	Explanation from Focus Groups
1. Firm employees' capability.	KBS firm employee's demonstrated capability to perform their work on previous contracts.	Employees within a KBS firm are capable to perform the required work described in the contract. They have the means necessary. They can do what we direct them to do.
2. Firm employees' ability to provide intelligent solutions.	KBS firm employee's demonstrated ability to provide intelligent solutions to the customer on previous contracts.	Employees within a KBS firm provide expert advice and knowledge beyond what the customer could otherwise discover or create with organic capabilities. They fill a knowledge gap in the organization. They can tell us what we should be doing.
3. Firm employees' dependability.	KBS firm employee's dependability on previous contracts.	Employees within a KBS firm provide reliable service, when and as expected. They will do what is required.
4. Firm's understanding of customer organizational requirements.	KBS firm's demonstrated ability to understand the customer's organizational requirements on previous contracts.	The KBS firm has empathy and understanding for the specific requirements, processes and procedures of the customer's organization (i.e. the mission in defense terms). They understand the customer's motivations and goals. They understand what needs to be done and why.

We chose four levels of the attributes: high, reasonable, low, and neutral. These were based on the four levels of past performance confidence government buyers can arrive at per the Department of Defense Source Selection Guide. We elected to categorize three of the rating levels based on the key differentiating adjective in each confidence level description (i.e., high = substantial confidence, reasonable = satisfactory confidence, low = limited confidence). "Neutral" was kept for its clear and general meaning in terms of rating description. "No confidence" profiles were not offered as a choice because they would never be selected to move forward for further consideration for federal contract and are therefore not a realistic attribute level to offer respondents at the point in the source selection we are simulating.

The price attribute is a key component of any CBC survey. Price differences in competing offers for KBS can vary. In order to extract meaningful part-worths, we conducted market research in a public procurement setting. We looked at actual data from Air Force installation contracting offices to determine the appropriate price delta to present in the offer profiles. This market research resulted in five price levels ranging from $18.53 million to $22.24 million, changing in 5% increments from a central price of $20.38 million. The total magnitude of the acquisition was based on a source selection scenario for 12 full-time equivalent (FTE) consultants to support the program management office of a large systems program office over a 12-month base period and four 12-month option periods. The total price shown also includes pricing for a six-month extension of service option if necessary. It is based on an average $150 per hour rate for consulting services, consistent with the high end of our market research. This scenario was developed out of the pretest in which respondents requested a scenario of sizeable enough magnitude to make a price-performance trade-off truly matter (thus the choice to include a higher hourly wage).

We also elected to include two price reference points for our respondents. In public procurement, buyers consider two reference values when assessing price: budget and government estimate. The government budget is the absolute amount of money allocated to an acquisition and the estimate is an independent assessment of what the government agency believes a reasonable price should be. In certain instances, offers may be considered that exceed the government estimate but must be within the budget. By providing these reference values we allowed our respondents to make choices within the budget constraint but over the estimate if they believe the non-price attribute value (utility) was worth the additional costs.

Data

The focal population for this research includes acquisition personnel for the government operating in B2G markets for KBS. These personnel served as either buyers, customers, program managers, or a combination of these roles. Our CBC survey ran from July 17, 2019 until November 15, 2019. A survey reminder was sent to the population on August 26, 2019. We received 1,717 responses (21.5% response rate). A subset of 636 of these respondents completed the CBC portion of the survey (7.96% response rate)[1].

The overwhelming majority of respondents served in buying agent roles as a contracting officer (CO=346) or contracting manager/administrator (CM/CA=305). Seventy-two served as end customers while 116 served in other, undescribed positions. The minority served as program managers (PM=42) and contracting officer representatives/quality assurance personnel (COR/QAP=31). Most respondents had 10 or fewer years of experience. Sixty-five had no direct experience with KBS providers. We considered the choice behavior of those with no direct experience still relevant because many buying agents make choice recommendations for the first time prior to any relevant experience as manager or customer of these services. The fact that most of our sample have direct KBS acquisition experience of 10 or fewer years was not unexpected or unusual. Most buying agents in this population do not specialize in KBS acquisition for their entire careers. We noted that two respondents had reported experience levels that were not feasible (99 and 100 years) leading us to eliminate them from our analysis.

To address the concern that some respondents may simply be randomly answering the CBC questions, we used an internal consistency fit statistic for reasonable likelihood (RLH) to identify random responders in our data (Orme, 2019). Sawtooth© software generated 297 random responses to our survey. Stata© was used to determine the average root likelihood (RLH) and 95% RLH cutoff for random responses using the generated set of random responses. These responses achieved an average RLH of 0.284 and 95th percentile cutoff of 0.336338. Orme (2019) recommends using this 95th percentile cutoff value to identify respondents who answer randomly. Five of the 636 responses were eliminated for low RLH, leaving a total CBC pool of 631 responses to be used for utility and willingness to pay calculations.

[1] The low completion rate was based on two overriding factors: 1) JavaScript requirements of the Sawtooth© software were blocked on some Air Force networks and 2) the time constraints placed on federal buying agents during the final fiscal year quarter. JavaScript blocks appear to have impacted 28% of non-completed respondents. This prevented respondents from moving past the introduction portion of the survey. The population were provided additional instructions to aid them in resolving the JavaScript issue, but many respondents did not attempt to complete it after their initial troubles. The remainder seem to have been impacted by the fiscal year time constraints based on informal polling. This is the busiest quarter of the fiscal year, and agents rush to obligate fiscal year funding before they expire. We were aware of this constraint but were forced to deploy the survey in this time frame based on the time constraints of the primary researcher.

Table 4: Respondent Willingness to Pay, Change in Shares, and Quality-Price Trade-offs Based on Perceived Service Quality Attributes

Panel 1: Marginal WTP by Attribute Level

WTP - Capability	Low	Neutral	Reasonable	High
Low				
Neutral	4.450403			
Reasonable	6.310466	1.7484347		
High	7.576713	2.8343906	1.058497	

WTP - Intelligence	Low	Neutral	Reasonable	High
Low				
Neutral	4.435991			
Reasonable	6.447763	1.6798825		
High	7.573535	2.7901056	1.1097298	

WTP - Dependability	Low	Neutral	Reasonable	High
Low				
Neutral	4.393207			
Reasonable	5.899822	1.2941148		
High	6.935977	2.1283119	0.83132362	

WTP - Understanding	Low	Neutral	Reasonable	High
Low				
Neutral	3.52467			
Reasonable	5.015444	1.2724589		
High	5.713935	2.0746117	0.82571912	

Panel 2: Change in Shares by Attribute Level

ΔShares - Capability	Low	Neutral	Reasonable	High
Low				
Neutral	0.45			
Reasonable	4.84	31.71		
High	7.79	52.18	36.22	

ΔShares - Intelligence	Low	Neutral	Reasonable	High
Low				
Neutral	0.91			
Reasonable	5.03	31.21		
High	7.94	51.88	35.99	

ΔShares - Dependability	Low	Neutral	Reasonable	High
Low				
Neutral	0.33			
Reasonable	3.51	23.38		
High	5.58	39.88	26.23	

ΔShares - Understanding	Low	Neutral	Reasonable	High
Low				
Neutral	0.29			
Reasonable	3.05	22.47		
High	5.03	40.07	27.22	

Panel 3: Quality-Price Tradeoff by Attribute Level

Tradeoff - Capability	Low	Neutral	Reasonable	High
Low				
Neutral	24%			
Reasonable	34%	9%		
High	41%	15%	6%	

Tradeoff - Intelligence	Low	Neutral	Reasonable	High
Low				
Neutral	24%			
Reasonable	35%	9%		
High	41%	15%	6%	

Tradeoff - Dependability	Low	Neutral	Reasonable	High
Low				
Neutral	24%			
Reasonable	32%	7%		
High	37%	11%	4%	

Tradeoff - Understanding	Low	Neutral	Reasonable	High
Low				
Neutral	19%			
Reasonable	27%	7%		
High	31%	11%	4%	

*Note: Marginal WTP reported is the median of 631 respondents
Change in shares (Δ) is calculated based on the median price offered ($20.38M). It is also reflective of an increase in level for only the attribute listed
(i.e. comparing low-to-neutral capability compares a profile with all low level ratings and one with all low level ratings except for capability set at neutral)
Tradeoffs are calculated based on WTP relative to the lowest possible price offered ($18.53M).

Attribute	WTPmin	WTPmedian	WTPmax	WTPmean	WTPstd.dev.
Capability	0.299861	4.0514631	43.33519	5.167808	4.411736
Intelligence	0.409775	4.1639442	48.5266	5.359632	4.753538
Dependability	0.227926	3.7404234	43.93012	4.787026	4.160798
Understanding	0.22898	3.1824856	36.38744	4.250234	4.033088

*Note: This table reports statistical values for total WTP by attribute.

Study 2 Findings

Willingness to Pay

Table 4 displays the results of the marginal willingness to pay (panel 1), change in shares (panel 2), and relative quality-price trade-offs calculated by attribute (panel 3). We can calculate a willingness to pay for each marginal level difference between attributes. We use the median price change between levels (i.e., $19.46 − $18.53 = 0.93, etc.) and the median utility change between levels (i.e., $18.53 million to $22.24 million) to arrive at a price per util. This is then multiplied by each marginal change in utility between levels from low to high. We note that willingness to pay is highest at all levels for employee capability and intelligent solution attributes (7.577 and 7.574 respectively). These two perceived quality attributes are very similar in terms of marginal willingness to pay, change in shares, and relative quality–price trade-offs at each attribute level. The highest willingness to pay occurs when moving between low to high levels of intelligent solutions. The largest quality–price trade-off occurs when moving between low to high levels of capability and intelligent solutions (41%). The marginal willingness to pay and trade-off for movements from reasonable perceived quality to high perceived quality is the most commonly observed trade-off scenario found in our field studies. The highest instance of this marginal willingness to pay occurs within the employee capability and intelligent solutions attributes (6% each). This information can now be used to arrive at QIP© calculated trade-offs in comparative offer scenarios.

Quality-infused Price Using KBSQual Scale

Thanks to this research we can now implement the concept of QIP© fully for B2G KBS. This paper offers the appropriate psychometrically sound scale for KBS perceived quality. It also offers factor levels (based on current DoD policy), monetized trade-offs relative to these levels, and appropriate mapping of the scores for this scale onto these monetized levels. Suppose we observe three firms providing the three simplified offers in Figure 2. Each firm has an offered price and an observed history of perceived KBS quality scores going back the full three years required. These scores are based solely on the factors determined to best represent perceived KBS quality from this study.

Firm 1 - Contract 1	2017	2018	2019	Average Score	Expectation
The firm's employees were capable.	7	5	6	5.83	Reasonable
The firm's employees provided intelligent solutions	5	5	6	5.50	Reasonable
The firm's employees were dependable.	6	6	6	6.00	Reasonable
The firm understood customer organizational requirements.	5	6	7	6.33	Reasonable
Firm 1 - Contract 2	**2017**	**2018**	**2019**	**Average Score**	**Expectation**
The firm's employees were capable.	7	7	7	7	High
The firm's employees provided intelligent solutions	6	6	7	6.5	High
The firm's employees were dependable.	6	6	6	6	Reasonable
The firm understood customer organizational requirements.	6	6	6	6	Reasonable
Firm 1 - Contract 3	**2017**	**2018**	**2019**	**Average Score**	**Expectation**
The firm's employees were capable.	5	6	6	5.83	Reasonable
The firm's employees provided intelligent solutions	5	5	5	5.00	Low
The firm's employees were dependable.	6	6	6	6.00	Reasonable
The firm understood customer organizational requirements.	5	6	5	5.33	Low
Firm 2 - Contract 1	**2017**	**2018**	**2019**	**Average Score**	**Expectation**
The firm's employees were capable.	7	7	6	6.5	High
The firm's employees provided intelligent solutions	7	7	6	6.5	High
The firm's employees were dependable.	7	7	7	7	High
The firm understood customer organizational requirements.	7	7	7	7	High
Firm 2 - Contract 2	**2017**	**2018**	**2019**	**Average Score**	**Expectation**
The firm's employees were capable.	7	7	7	7.00	High
The firm's employees provided intelligent solutions	6	7	7	6.83	High
The firm's employees were dependable.	6	7	7	6.83	High
The firm understood customer organizational requirements.	6	6	7	6.50	High
Firm 2 - Contract 3	**2017**	**2018**	**2019**	**Average Score**	**Expectation**
The firm's employees were capable.	7	7	7	7	Reasonable
The firm's employees provided intelligent solutions	6	7	7	6.83	High
The firm's employees were dependable.	7	7	7	7	High
The firm understood customer organizational requirements.	6	6	6	6	Reasonable

Capability	Intelligence	Dependability	Understanding
6.22	5.67	6.00	5.89
Reasonable	Reasonable	Reasonable	Reasonable
Price offered			
$ 1,375,000.00			

Capability	Intelligence	Dependability	Understanding
6.83	6.72	6.94	6.50
High	High	High	High
Price offered			
$ 1,450,000.00			

Firm 3 - Contract 1	2017	2018	2019	Average Score	Expectation
The firm's employees were capable.	5	5	6	5.50	Reasonable
The firm's employees provided intelligent solutions	5	5	5	5.00	Low
The firm's employees were dependable.	5	5	7	6.00	Reasonable
The firm understood customer organizational requirements.	5	6	6	5.83	Reasonable
Firm 3 - Contract 2	**2017**	**2018**	**2019**	**Average Score**	**Expectation**
The firm's employees were capable.	5	6	6	5.83	Reasonable
The firm's employees provided intelligent solutions	6	6	6	6.00	Reasonable
The firm's employees were dependable.	6	7	7	6.83	High
The firm understood customer organizational requirements.	6	6	7	6.50	High
Firm 3 - Contract 3	**2017**	**2018**	**2019**	**Average Score**	**Expectation**
The firm's employees were capable.	5	5	5	5.00	Low
The firm's employees provided intelligent solutions	5	5	6	5.50	Reasonable
The firm's employees were dependable.	6	5	6	5.67	Reasonable
The firm understood customer organizational requirements.	5	5	5	5.00	Low

Capability	Intelligence	Dependability	Understanding
5.44	5.50	6.17	5.78
Low	Reasonable	Reasonable	Reasonable
Price offered			
$ 1,200,000.00			

Figure 2: Individual Offer Rating Sheet Example

The panes on the left of each table within Figure 2 represent a time-weighted average score for each perceived quality factor on each contract. These scores are weighted as 0.50 for $year_0$, 0.3333 for $year_{t-1}$, and 0.1666 for $year_{t-2}$. Scores could be weighted in a variety of ways to consider more recent scores. For instance, we could also use a base of 36 months (three years) from the submission date of the offers and weight each past performance submission recency based on the number of months from the date of submission (i.e., an offer with a rating dated only a month prior to submission would be weighted 35/36th and a rating that met the minimum three-year requirement from submission would be weighted 1/36th). The expectation level is based on the ratings used in our study that were derived from the DoD Source Selection Guide Table 5 definitions. The pane on the right of each table demonstrates the average of each time-weighted factor score over the observable contract history (in our case three contracts each).

Note that Firm 1 has a medium-high price with reasonable quality ratings on all four perceived quality factors. Firm 2 has the highest price (beyond the government estimate) with high quality ratings on all four perceived quality factors. Firm 3 has the lowest price (still within realism standards) and demonstrates a history of low perceived quality on employee capability but reasonable perceived quality on the remaining three factors. Using these averages, we can now compare each offeror's relative value using the trade-offs calculated in study 2 (see Table 5).

Table 5: Example of QIP© Trade-offs Using KBSQual Scale

Firm 1			
Capability	Intel	Depend	Understanding
6.2	5.7	6.0	5.9
Reasonable	Reasonable	Reasonable	Reasonable
Price offered			
$ 1,375,000.00			

	Vs. Firm 2	Vs. Firm 3
Capability Value	$ (49,500.00)	$ 319,800.00
Intel Value	$ (310,062.50)	$ 84,000.00
Depend Value	$ (49,500.00)	$ 9,600.00
Understand Value	$ (127,875.00)	$ 32,400.00
Trade Space	$ (536,937.50)	$ 445,800.00

Firm 2			
Capability	Intel	Depend	Understanding
6.8	6.7	6.9	6.5
High	High	High	High
Price offered			
$ 1,450,000.00			

	Vs. Firm 1	Vs. Firm 3
Capability Value	$ 49,500.00	$ 344,400.00
Intel Value	$ 310,062.50	$ 295,200.00
Depend Value	$ 49,500.00	$ 16,800.00
Understand Value	$ 127,875.00	$ 130,200.00
Trade Space	$ 536,937.50	$ 786,600.00

Firm 3			
Capability	Intel	Depend	Understanding
5.4	5.5	6.2	5.8
Low	Reasonable	Reasonable	Reasonable
Price offered			
$ 1,200,000.00			

	Vs. Firm 1	Vs. Firm 2
Capability Value	$ (319,800.00)	$ (344,400.00)
Intel Value	$ (84,000.00)	$ (295,200.00)
Depend Value	$ (9,600.00)	$ (16,800.00)
Understand Value	$ (32,400.00)	$ (130,200.00)
Trade Space	$ (445,800.00)	$ (786,600.00)

Offers Compared	Price Deltas	Trade space	Value Captured	Scenario Choice
Firm 1 and 2	$ (75,000.00)	$ 536,937.50	$ 461,937.50	Firm 2
Firm 1 and 3	$ 175,000.00	$ 445,800.00	$ 270,800.00	Firm 1
Firm 2 and 3	$ 250,000.00	$ 786,600.00	$ 536,600.00	Firm 2

Value Rank-Final		Rationale
Firm 2	Best Value	$461,937.50 of perceived value captured over next best offer
Firm 1		
Firm 3		

Trade space is calculated for each offer relative to the other. We define trade space as *the relative willingness to pay we would assume over and above the lowest price in a comparison of offers based on their perceived KBS quality ratings*. It is the maximum extra price we would recommend the agency (in our case the DoD) be willing to pay to get the capability level offered by Firm 2 instead of the level offered by Firm 1. Based on this we can see that Firm 1 has negative trade space on all perceived quality factors relative to Firm 2 and all positive trade space relative to Firm 3. Trade space is calculated by taking the range of score averages between evaluated firms and multiplying it by the total trade-off percentages calculated in study 2 and the lowest price of comparison.

The ranges were established using a mapping of the KBS quality scores used in our first study survey (Likert ratings from 1-strongly disagree to 7-strongly agree) to the ratings based on the DoD Source Selection Guide (i.e., low, neutral, reasonable, and high) used in our CBC study in study 2. (See Table 6.) Study 2 also provides calculations of willingness to pay in dollars and trade-off percentages from level to level (i.e., low to reasonable, low to high, etc.). Using this mapping, we establish the within-range scores for low to reasonable as 5 to 6 in 0.1 increments (base of 10) and interpolate the trade-off (see Table 7.) For example, if a Capability rating of 5.1 is compared to a rating of 6, we refer to Table 4's trade-off percentage of 34% between low and reasonable levels, and then weight this trade-off by the range we are covering. Since the range of 6 to 5.1 is 0.90, so is the weight. This 0.90 weight is applied to the Capability full range trade of 34% to yield a weighted range trade of 30.6%. We establish the within-range scores for reasonable to high as 6 to 7 in the same 0.1 increments relative to the within-range trades offered in Table 4. For scores that cross ranges from 5 to 7, we use a range of 20 (i.e., 5 to 7 in 0.1 increments). If we observe a score in the range between 5 and 6 that is compared to a score between 6 and 7, we use the range of 20 (i.e., a score of 5.2 compared to a score of 6.3).

To calculate the relative trade-off, we multiply these weighted values by the lowest price being compared—for example, if Firm 1's aggregate Capability rating is 6.2 and Firm 2's Capability rating is 6.8. This creates a within-range weight of 0.6 (6.8 to 6.2). The relative trade-off within the range from reasonable to high (6 to 7) is a maximum of 6% based on study 2 findings (Table 4 and Table 7). Therefore, we calculate the trade space between Firm 1 and Firm 2 for Capability to be (6%*(6/10))*$1,375,000.00, or −$49,500.00. We use Firm 1's price of $1,375,000.00 to calculate the trade space because we are calculating how much we should be willing to pay over and above their price given the higher perceived quality ratings of Firm 2. In this case we see that, for the Capability factor, Firm 1 has negative trade space relative to the higher priced Firm 2. Firm 2's trade space is simply the positive $49,500.00 calculated. Trade space will always be equal and opposite between compared firms for each perceived quality factor. Total trade space is then compared to price differences to assess the value of a higher priced offer when they demonstrate a past performance of higher perceived service quality.

Next, we clearly estimate the value captured. Value captured is defined as *the difference in the evaluator's total trade space and the price difference between two compared offers.* So, in the example above, we see that we can capture $461,937.50 of value over and above the extra price paid (i.e., we pay $75,000.00 more for Firm 2 over Firm 1 but we should be willing to pay $536,937.50 given Firm 2's perceived quality scores relative to Firm 1). The same holds true for Firm 2 over Firm 3 to a greater degree as we would expect given Firm 3's lower perceived quality factor scores. The value captured measure is of utmost importance in public procurement. This is essentially the quantified rationale for why the buying agency paid more for one offer over another in clear terms that is based on perceived measures. For instance, in this scenario, it would be very reasonable for the buying agency to select Firm 2 even though it is slightly higher than their estimate, yet within budget.

Table 6: Mapping of Perceived KBS Quality Scales and Levels

Agreement Scale	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Numeric Scale	1	2	3	4	5	6	7
KBS Perceived Quality Attributes	Percentiles						
Understanding	1%	1%	5%	10%	25%	50%	75%
Capability	1%	1%	5%	10%	25%	50%	75%
Dependability	1%	1%	5%	10%	25%	50%	75%
Intelligent Solutions	1%	1%	5%	10%	25%	50%	75%
DOD SS Guide Confidence Level	No Confidence			Neutral Confidence	Limited Confidence	Satisfactory Confidence	Substantial Confidence
CBC Rating Level	Not Assessed			Neutral	Low	Reasonable	High

Table 7: Trade Interpolations Across Rating Ranges

	Interpolation	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
Low to Reason	5	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	5 vs. 6
Capability	34%	30.600%	27.200%	23.800%	20.400%	17.00%	13.600%	10.200%	6.800%	3.400%	34%
Intelligence	35%	31.500%	28.000%	24.500%	21.000%	17.50%	14.000%	10.500%	7.000%	3.500%	35%
Dependability	32%	28.800%	25.600%	22.400%	19.200%	16.00%	12.800%	9.600%	6.400%	3.200%	32%
Understanding	27%	24.300%	21.600%	18.900%	16.200%	13.50%	10.800%	8.100%	5.400%	2.700%	27%

Capability Example: Within confidence ranges will be assessed as the total range value * the proportion of the range that is being covered. (i.e. 5.1 vs. 5.3 = 34%*(2/10) = 6.8% trade.

	Interpolation	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	
Low to High	5	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	5 vs. 7
Capability	41%	38.9500%	36.9000%	34.8500%	32.8000%	30.7500%	28.7000%	26.6500%	24.6000%	22.5500%	20.5000%	18.4500%	16.4000%	14.3500%	12.3000%	10.2500%	8.2000%	6.1500%	4.1000%	2.0500%	41%
Intelligence	41%	38.9500%	36.9000%	34.8500%	32.8000%	30.7500%	28.7000%	26.6500%	24.6000%	22.5500%	20.5000%	18.4500%	16.4000%	14.3500%	12.3000%	10.2500%	8.2000%	6.1500%	4.1000%	2.0500%	41%
Dependability	37%	35.1500%	33.3000%	31.4500%	29.6000%	27.7500%	25.9000%	24.0500%	22.2000%	20.3500%	18.5000%	16.6500%	14.8000%	12.9500%	11.1000%	9.2500%	7.4000%	5.5500%	3.7000%	1.8500%	37%
Understanding	31%	29.4500%	27.9000%	26.3500%	24.8000%	23.2500%	21.7000%	20.1500%	18.6000%	17.0500%	15.5000%	13.9500%	12.4000%	10.8500%	9.3000%	7.7500%	6.2000%	4.6500%	3.1000%	1.5500%	31%

	Interpolation	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
Reason to High	6	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	6 vs. 7
Capability	6%	5.400%	4.800%	4.200%	3.600%	3.00%	2.400%	1.800%	1.200%	0.60%	6%
Intelligence	6%	5.400%	4.800%	4.200%	3.600%	3.00%	2.400%	1.800%	1.200%	0.60%	6%
Dependability	4%	3.600%	3.200%	2.800%	2.400%	2.00%	1.600%	1.200%	0.800%	0.40%	4%
Understanding	4%	3.600%	3.200%	2.800%	2.400%	2.00%	1.600%	1.200%	0.800%	0.40%	4%

Capability Example: Between scores that cross a range threshold would be treated as the full range tradeoff multiplied by the fraction of the range covered. (i.e. 5.1 to 6.1 is equal to 21% trade or 41% *(10/20).

Overall Findings and Contributions

We were able to address the four primary questions:

1) KBS is defined as *those services in which the primary medium of exchange is a transfer of expert advice, knowledge, processes, or information. Such services are generally low in capital intensity and high in knowledge intensity.*
2) KBS manifests as a second-order factor construct consisting of employee capability, employee ability to offer intelligent solutions, employee dependability, and the firm's understanding of the customer's organizational requirements.
3) These first-order factors are distilled into a single indicator for each factor for efficiency and effectiveness.
4) Using WTP calculations from a sample of 631 public buying agents we have monetized the first-order factors of perceived KBS quality for use in source selections.

A full list of contributions to managers and the literature is available in the author's dissertation manuscript.

Conclusions

Up unto this point, the concept of using perceptions of quality has been rarely used and never in a manner in which the trade-offs were calculated using true empirical utilities from the population. Previous trade-off percentages were ad hoc and unique to each buying team. The methods, trades, and value capture rationale offered here provide the strongest, most defensible approach to date and should be replicated in other service environments. This guards against the protest risk inherent in typical tradeoff evaluations by giving more transparency into the buying agencies' best value determinations.

The use of this scale and suggested monetization approach bolsters the potential for QIP© to change the landscape of service acquisition within public procurement. The methods used in these studies can, and should, be replicated for other high-spend service portfolios within the government such as equipment services, sustainment services, and logistics services. It should also be considered by firms in B2B markets. If agencies can articulate and translate perceptions of quality into monetary value, they can aid their customers in getting the best-value service solution while offering firms a clear picture of where they stand relative to their competition in matters of perceived service quality that are paramount in highly operant services like KBS.

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