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A Factor Analysis of Key Decision Factors for Implementing SOA-based Enterprise level Business Intelligence Systems

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ABSTRACT

The implementation of Service-oriented Architecture (SOA) for enterprise-level Business Intelligence (BI) system enables a low-cost and flexible BI system. However, the key decision factors (KDF) for implementing SOA-based BI architecture from technical perspectives have not yet been systematically investigated. Correspondingly, a 32-item instrument (KDF-SOABI) was developed from literature review and distributed to 200 companies in Malaysia to identify the key decision factors for SOA-based BI system. The sixty-two responding samples were analysed using exploratory factor analysis method. As a result, a two-factor solution was revealed. The research finding suggests that the KDF-SOABI consists of two separate factors (namely, operational factors and performance factors) which account for 63.826% of the total scale variance. The result provides an initial evidence of the factor structure.

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INTRODUCTION

Business intelligence (BI) is an umbrella term that involves various analytics software components being utilized to turn large volume of data into information. At the meantime, BI architecture has evolved from conventional two-tier architecture to Service-Oriented Architecture (SOA). An SOA-based BI system enables a lowcost, flexible and standardised system that supports various BI components integration and data sharing. However, the key decision factors (KDF) for implementing an SOA-based BI architecture from technical perspectives have not yet been systematically investigated. Therefore, the main aim of this paper is to explore the factor structure and identify the KDF for SOABI. In doing so, a questionnaire survey was conducted to identify the KDF for SOA-based BI systems (KDF-SOABI). The survey respondents include IT professionals, MIS managers, IT executives, Chief Information Officers (CIO) and business personnel who have experience in implementing an SOA-based BI system.

Method:

On the basis of previous work (Chan *et al*. 2012, Chan *et al*. 2011), the authors developed a multi-item scale for each variable included in the model. A 32-item measurement instrument was developed to assess the key decision factors for SOA-based BI systems under two main dimensions of interest, namely operational dimension and performance dimension. Email invitations and printed questionnaire were sent to a random sample of 200 enterprises in Malaysia. Sixty-two participants responded to the survey, resulting in 31% response rate. The data was subjected to reliability analysis and Exploratory Factor Analysis (EFA). EFA was used to examine the factorial validity of the KDF-SOABI. EFA is a multivariate statistical approach which serves as a starting point in examining the factor structure of the instrument.

Data Collection:

The target population for this study includes IT/IS professionals, who have involved in the implementation of SOA-based BI systems. Data was collected from a range of industries and organizations within Malaysia. A survey instrument was designed based on a literature review.

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Specifically, a total of 32 items were generated from the literature that fall under the domain of two main dimensions. The survey questions consist of two sections with a total of 59 questions. 32-item scale were measured on a six-point Likert scale from "not applicable", "strongly disagree" to "strongly agree". A 32-item scale instrument was developed to assess the KDF-SOABI model.

Analysis:

The KDF-SOABI survey was responded by 62 participants. Data were subjected to Exploratory Factor Analysis (EFA) technique. The factor structure of the KDF-SOABI was examined by subjecting the initial scale to EFA. EFA was conducted to identify the factors on which the item to be loaded. The cumulative amount of score variance for different factors and scree plot were utilized to determine the factors adopted. Varimax rotation with Kaiser normalization was performed. The factor matrix was examined in order to identify the constructs represented by each factor. Internal consistency coefficients (Cronbach's alpha) were acquired to assess the reliability of the scale. This study employed the use of reliability analysis in determining the retention or removal of items on the scale. "Corrected Item-total Statistics" (CIS) and "Cronbach's Alpha if Item Deleted" (CAID) were examined before taking item retention decision on each of the items. Any item having CIS of less than 0.2 was removed from the scale. The implication of this is that the Alpha coefficient of the scale increased when such items were deleted.

RESULT AND DISCUSSION

Demographics of respondents:

Most of the participants of the study (N = 62) are male 88.7%. With regards to the education level, the participants are generally well-educated (25% certificate/diploma level; 45.2% bachelor's degree holder; 29.0% post-graduate degree holder). Majority (61.29%) of the participants have over 5 years of experience in the implementation of BI systems. About 42.2% of the participant's companies have completed BI implementation between the last 2 to5 years.

Reliability Test:

This study uses Cronbach's alpha to measure reliability and the reliability is found to be 0.804, as depicted in Table 1. Cronbach's alpha is calculated to determine the internal consistency of the score. The alpha coefficient is greater than 0.70 (Gable and Wolf 1993). Thus, the responded samples are suitable for the purpose of identifying the KDF-SOABI key factors.

Table 1: Reliability Test for 32-item KDF-SOABI.
Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.804	.823	32

As shown in Table 2, item 27 has the highest standard deviation (1.434). While mean responses differed mostly on item 27. Some agreed strongly with it while others did not. The study employed reliability analysis in determining the retention or rejection of item on the scale. Any item with a 'corrected item-total correlation' of less than 0.2 in Table 3 was marked as an item to be deleted. With the deletion of these items, the scale's Cronbach's alpha and mean could be increased. The 'corrected item-total correlation' of each of the subscale was considered leading to the decision of removing 8 items off the construct, resulting to the retention of 24 items on the second version of the construct. A Cronbach's alpha of 0.831 was obtained, as shown in Table 4.

As shown in Table 5, the item-total statistics of the 14-item final version are very similar. The 'scale mean if item deleted' for each items is 51. The 'Corrected Item-Total Correction' for each of the items ranges between 0.372 to 0.814; meaning that the items have almost equal psychometric values in the scale (Table 5). Table 6 summarizes the results of 4 runs of reliability analysis and the Cronbach's alpha is 0.901 on the final 14-items version. After the reliability analysis, the number of items subjects to the 2nd round factor analysis is 24. A further reduction of the items of the scale led to the 14-items final version. Based on the results of 4 runs of reliability analysis, 18 items were removed (item 1,2,3,4,5,8,10,11,12,14,20,21,22,23,24,28,31,32).

Table 2: Item Mean and Standard Deviation for the 32-item version of KDF-SOABI.

Variable	Mean	Std. Deviation	Item-to-total correlation	Communalities
Item 1	4.19	.865	.160	.212
Item 2	3.73	.682	-.036	.004
Item 3	4.34	.676	.040	.304
Item 4	4.10	.469	.085	.051

Item 5	3.82	.820	.011	.063
Item 6	4.32	.471	.251	.564
Item 7	3.87	1.123	.752	.617
Item 8	3.44	.590	.586	.469
Item 9	3.94	.990	.786	.539
Item 10	3.92	.911	.143	.026
Item 11	3.92	.522	.221	.052
Item 12	4.15	.674	.232	.456
Item 13	4.23	.688	.704	.717
Item 14	4.06	.787	.262	.481
Item 15	4.10	.670	.588	.563
Item 16	4.03	.724	.606	.611
Item 17	4.05	.931	.387	.743
Item 18	4.06	.827	.627	.764
Item 19	4.11	.704	.548	.570
Item 20	4.84	.371	.241	.211
Item 21	4.84	.371	.241	.211
Item 22	4.61	.686	-.070	.044
Item 23	3.16	1.357	.374	.620
Item 24	3.29	.948	.212	.271
Item 25	4.27	.728	.591	.535
Item 26	3.87	1.166	.412	.775
Item 27	3.55	1.434	.257	.604
Item 28	3.66	1.342	.006	.241
Item 29	3.97	.600	.510	.480
Item 30	3.84	.682	.542	.593
Item 31	3.58	.759	.078	.129
Item 32	4.03	.868	-.093	.076

Table 3: 1st run of Item-Total Statistics for 32-item version of KDF-SOABI.
Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Item 1	123.69	97.921	.160	.805
Item 2	124.16	101.449	-.036	.810
Item 3	123.55	100.416	.040	.807
Item 4	123.79	100.398	.085	.805
Item 5	124.06	100.553	.011	.810
Item 6	123.56	98.840	.251	.801
Item 7	124.02	84.606	.752	.775
Item 8	124.45	94.350	.586	.792
Item 9	123.95	86.014	.786	.776
Item 10	123.97	97.999	.143	.806
Item 11	123.97	98.851	.221	.802
Item 12	123.74	97.867	.232	.801
Item 13	123.66	91.670	.704	.786
Item 14	123.82	96.738	.262	.800
Item 15	123.79	93.349	.588	.790
Item 16	123.85	92.454	.606	.789
Item 17	123.84	93.580	.387	.795
Item 18	123.82	90.837	.627	.786
Item 19	123.77	93.456	.548	.791
Item 20	123.05	99.489	.241	.802
Item 21	123.05	99.489	.241	.802
Item 22	123.27	101.907	-.070	.811
Item 23	124.73	89.940	.374	.797
Item 24	124.60	96.572	.212	.803
Item 25	123.61	92.602	.591	.789
Item 26	124.02	90.901	.412	.794
Item 27	124.34	92.293	.257	.805

Item 28	124.23	99.456	.006	.819
Item 29	123.92	95.092	.510	.794
Item 30	124.05	93.785	.542	.791
Item 31	124.31	99.659	.078	.807
Item 32	123.85	102.290	-.093	.814

Table 4: Reliability Test after deletion of nine items for 24 items with p<0.05

Cronbach's Alpha	N of Items
0.831	24

Table 5: 4th run of Item-Total Statistics of KDF-SOABI (14 items)
Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Item 7	51.45	53.989	.688	.891
Item 8	51.89	60.495	.629	.895
Item 9	51.39	55.749	.669	.891
Item 13	51.10	59.597	.617	.895
Item 15	51.23	58.997	.696	.892
Item 16	51.29	57.586	.775	.889
Item 17	51.27	56.563	.656	.892
Item 18	51.26	55.867	.814	.886
Item 19	51.21	59.578	.602	.895
Item 25	51.05	59.522	.584	.895
Item 26	51.45	53.596	.683	.891
Item 27	51.77	54.801	.460	.909
Item 29	51.35	62.724	.372	.902
Item 30	51.48	61.172	.467	.899

Table 6: The summary of 4 runs of Item-Total Statistics of KDF-SOABI

	Number with Corrected Item-Total Correlation	Number Of Item to be Item Removed	Number Of Item Retain	Cronbach's Alpha
1st run of Item-Total Statistics for 32-item version	9	9	23	0.831
2nd run of Item-Total Statistics	7	7	16	
3rd run of Item-Total Statistics	2	2	14	
4th run of Item-Total Statistics fir final 14-item version	0	0	14	0.901

Factor analysis is a multivariate statistical method for reducing a large number of variables into a smaller set of factors in questionnaires and therefore establishing underlying dimensions between observed variables and latent dimensions. Variables with similar characteristics will be gathered together which is capable of explaining the observed variance in the larger number of variables. Hence, the reduced factors can be applied for further analysis (Williams *et al*. 2010). In line with this concept, the data generated from the administration of the 32-item KDFSOABI was subjected to factor analysis. The initial unrotated factor solution using Principal Component Analysis suggested 10 factors (with eigenvalue greater than one), which accounts for 94.365 % of the total scale variance. However, the scree plot (Figure 1) produces two significant factors only. The scree plot is a graph for determining how many factors to retain. Principal Component Analysis with Varimax rotation that produced the final 14-items version suggested 2 main types of factor as shown in Figure 2.

The purpose of the data extraction is to eliminate a huge number of items into distinct factors. Table 7 demonstrates a cumulative percentage of variance of 63.826% and a total of 2 components (factors) having an eigenvalue > 1. The "Extraction Sums of Squared Loadings" which represents the "work" done by the factor analysis. The first eigenvalue is equal to 6.280, and corresponds to 44.855% of the variance in the original data. The second eigenvalue 2.656, corresponding to the second factor, is associated with 18.971% of the variance in the original data. Together, the first two factors explain 63.826% of the variance in the original data. All the remaining factors are not significant.

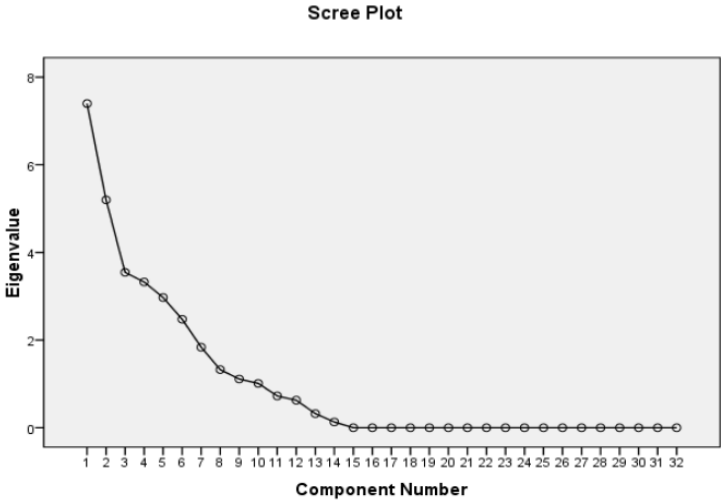

Fig. 1: Scee plot for the 32-item version of scale (with eigenvalues greater than one).

Table 7: Total Variance Explained of 2-factor solution having an eigenvalue > 1.

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	% of Variance	Cumulative %
1	6.280	44.855	44.855	6.280	44.855	44.855	5.033	35.953	35.953
2	2.656	18.971	63.826	2.656	18.971	63.826	3.902	27.873	63.826

Extraction Method: Principal Component Analysis.

In Figure 2, the inspection of the Scree plot and eigenvalues produced a departure from linearity coinciding with a 2-factor result. Therefore this Scree Test indicates the data that should be analysed include only 2 factors. Orthogonal varimax rotation was used since we believe that the factors should be theoretically independent (unrelated to each other). The results of an orthogonal rotation of the solution are shown in Table 8. When loadings less than 0.30 were excluded, the analysis yielded a two-factor solution with a simple structure (factor loadings =>.30). Seven items that loaded onto Factor 1 were labeled as "Operational". Seven items that were loaded onto Factor 2 were labeled "Performance". Items with factor loadings on Factor 1 were related to operational (item 6,7,9,13,15,16,17) and Factor 2 included items relating performance (item 18,19,25,26,27,29,30). Cronbach's alpha is 0.901; indicating an excellent overall internal consistency for the final 14-item KDF-SOABI and good internal consistency for the two-factor structure (Factor 1 = 0.885; Factor 2 = 0.697).

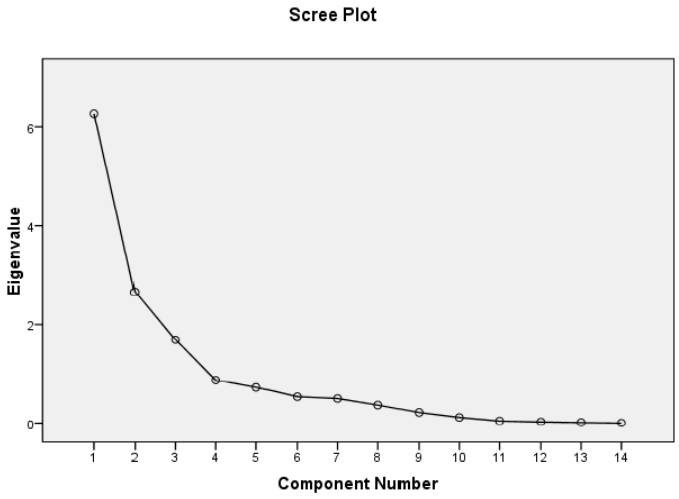

Fig. 2: Scee plot for the 14-item version of scale.

Table 8: Exploratory factor analysis factor loading, eigenvalues, variance extracted and Cronbach's Alpha (sample n=62).

Variable	Item description	Factor Loading		
		Factor 1	Factor 2	Communalities
Item 6	BI system has to deliver a single common view throughout an entire organization.	0.79	-0.23	0.67
Item 7	A common view in BI system is important to ensure the data validity and data quality.	0.66	0.41	0.60
Item 9	BI system has to be compatible with other information systems or applications such as planning and budgeting system.	0.60	0.4	0.52
Item 13	BI system should be able to support information retrieval in a broad range of formats.	0.41	0.67	0.62
Item 15	BI system has to adapt to the changes when a new business strategy is implemented.	0.66	0.3	0.53
Item 16	BI system has to adapt to the changes when a new enterprise application is implemented.	0.74	0.36	0.68
Item 17	BI administrator should be able to manage BI architecture effectively.	0.82	-0.07	0.67
Item 18	BI administrator should be able to identify potential technical issues proactively before they become problems.	0.32	0.82	0.78
Item 19	BI administrator should be able to maintain optimal system performance.	0.51	0.53	0.54
Item 25	BI system has to operate regularly on a 24x7 basis.	0.36	0.66	0.56
Item 26	BI system has to operate regularly except of scheduled maintenance.	0	0.82	
Item 27	Certain critical portions of BI system should be available during scheduled maintenance.	-0.31	0.77	0.68
Item 29	BI system has to remain responsive after extending the system functionalities.	0.05	0.77	0.60
Item 30	BI system has to remain responsive after extending the system sophistication or complexity.	0.14	0.88	0.80
Eigen value		6.280	2.656	
% of variance		44.855%	18.971%	
Cronbach's alpha		0.885	0.697	
Extraction method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. No item to total correlation <0.30.				

Conclusion:

This paper presents a preliminary result of the acceptable psychometric properties of a new survey instrument to assess the key decision factors for implementing SOA-based enterprise-level Business Intelligence systems. The exploratory factor analysis of this research suggests that there are two main types of factor which account for 63.826% of the total variance. A two-factor solution was revealed. Also, the scree plots depicts that there are two factors which are labelled as "operational" and "performance" factor. The result shows that the KDF-SOABI survey instrument developed for this study is a valid and reliable measurement. Our findings allow us to conclude that the resulting 14-items scale with Cronbach's alpha correlation coefficients of 0.901 is a much more reliable instrument than the initial 32-items scale. Confirmatory Factor Analysis (CFA) should be utilized in future studies by replicating these factor structure findings in a larger sample size.

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